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The Canadian Entomologist

Vol. XCII Ottawa, Canada, January 1960 No. 1

Survival, Fecundity, and Population Growth of *Melanoplus bilituratus* (Wlk.) (Orthoptera : Acrididae) in Relation to Date of Hatching[1]

By R. PICKFORD
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In Western Canada, *Melanoplus bilituratus* (Wlk.) may hatch from early May to mid-July, depending on seasonal conditions. Little information is available on the relationship of time of hatching to population growth except that grasshoppers emerging too early in the spring may be destroyed by adverse weather that often occurs at this time (Shotwell, 1941). Also, it has been assumed that grasshoppers hatching late in the summer mature too late to contribute much to general population growth.

Laboratory studies (Pickford, 1958) suggested that the high inherent reproductive potential of this species might explain rapid population growth, yet the results obtained by Pfadt (1949), Smith *et al.* (1952), and Drake *et al.* (1945) indicated that only a small proportion of this potential was realized under field conditions.

This report deals with a series of field cage experiments conducted over a three-year period from 1956 to 1958 at Saskatoon to investigate further the survival, fecundity and population growth of *M. bilituratus*, especially in relation to time of hatching.

Methods

Newly-hatched grasshoppers were placed in field cages at approximately two-week intervals from May to July. Each hatching date treatment consisted of 100 grasshoppers per cage replicated four times and arranged in a randomized block design. The dates on which the grasshoppers were placed in the cages are shown in Table I.

The cages, two feet square and 2½ feet high, were constructed of a wooden frame and 20-mesh-per-inch plastic screening. They were placed over a mixture of growing cereal grains and weeds in a field near Saskatoon. The vegetation in the cages was thinned when necessary to prevent it from becoming too dense, and was removed completely from a narrow strip along the front and sides to provide an open area where the grasshoppers could sun themselves and oviposit.

In 1956, grasshoppers descended from stocks from the Princeton and Lac du Bois regions of interior British Columbia were used. The vegetation inside the cages consisted of Thatcher wheat and wild mustard, *Brassica kaber* (DC.) L.C. Wheeler var. *pinnatifida* (Stokes) L.C. Wheeler. About mid-August when most of the vegetation was ripening, the cages and grasshoppers were moved to a nearby field and placed over a mixture of grains and weeds, mainly rye, oats, barley, and round-leaved mallow, *Malva rotundifolia* L. The grasshoppers remained in the field cages until October 22; at this time survival ranged from 18 to 57 per cent. Fourteen females and seven males from each treatment were then placed in laboratory cages (Pickford, 1958) and allowed to oviposit until all were dead.

[1]Contribution No. 29, Canada Department of Agriculture Research Station, Saskatoon, Sask.

TABLE I
Development, survival, and duration of stages of *M. bilituratus* hatched on various dates

Date hatched	Origin of grasshoppers	Per cent survival of nymphs from hatching to adult	Days duration of nymphal stage	Per cent survival of adults for two month period from last moult	Days duration of adult female life
May 31, 1956	Interior	65	54	74	77
June 11	B.C.	61	63	78	45
June 20		27	59	57	62
June 30		50	51	49	55
July 10		61	61	31	28
July 20		50	63	53	22
May 5, 1957	Delisle,	61	55	85	99
May 18	Sask.	56	53	89	91
May 30		40	49	84	90
June 12		48	44	80	78
June 25		41	37	85	70
July 9		31	39	90	63
May 5, 1958	Delisle,	79	45	85	101
May 18	Sask.	75	45	90	84
June 3		57	43	79	77
June 17		59	40	84	81
July 2		40	38	83	65
May 16, 1958	Lily Plain,	89	42	93	90
June 3	Sask.	75	40	71	72
June 17		64	38	83	73
July 2		51	35	90	73

In 1957, grasshoppers descended from stocks from the Delisle area of central Saskatchewan were used. The vegetation inside the cages consisted of Kharkov wheat and wild mustard. Kharkov wheat is a winter variety which, when planted in the spring, acts as a biennial, remaining green throughout the season. The wild mustard was severely defoliated by an outbreak of flea beetles in the cages about the middle of August and was replaced by dandelion, *Taraxacum officinale* Web. This experiment was concluded on October 21 when most of the grasshoppers were destroyed by cold weather.

In 1958, grasshoppers from two different stocks were used separately; one stock originated from the Delisle area and the other from the Lily Plain area west of Prince Albert, Saskatchewan. Vegetation in these cages was similar to that in 1957. This experiment was concluded on November 13 when all grasshoppers had perished.

Survivors in the cages were counted when they were entering the adult stage to determine nymphal survival, and again two months later to measure adult survival over this period. Additional counts were made at various times during nymphal and adult stages.

When the grasshoppers became adult in 1956 and 1957, all females plus half as many males were returned to the cages for mating and oviposition; in 1958, however, only 15 females and nine males were replaced in each cage.

Egg-pods were recovered from the soil under the cages at the end of each experiment. In addition, in 1956 and 1958, cages were moved to new sites at various times and the eggs removed from the soil so that oviposition in different periods throughout the growing season could be measured.

The duration of the nymphal period was determined by counting the grasshoppers in each treatment when most were in the adult stage; from the number

of nymphs still present at this time an estimate was made of the number of days required for all grasshoppers to develop from hatching to the adult stage.

Grasshopper fecundity, or the average number of egg-pods per female, was calculated by dividing the total number of egg-pods recovered by the total number of females initially replaced in the cages in each treatment. The rate of oviposition, or the average number of eggs laid per female-day, was calculated to compare fecundity among treatments independently of the length of reproductive life.

The number of eggs per pod was ascertained by counting eggs in 10 to 30 pods from each treatment.

The hatchability of the eggs from each treatment was measured by the number of apparently healthy nymphs that hatched; quadruplicate samples of 50 eggs that had been kept under refrigeration for about three months to break diapause were incubated at 85° F.

Population growth was calculated from the product of the total number of females reaching the adult stage and the average number of eggs laid per female divided by the total number of nymphs initially placed in the cages.

The adult female life-span in each treatment was measured by plotting surviving grasshoppers against time. The area within the survival curve was measured to give the total number of female-days; this total divided by the initial number of adult females gave the average life-span.

Results and Discussion

Survival

Nymphs—The survival of grasshoppers during the period from hatching to the newly-emerged adult stage was consistently greatest among those hatched on the earliest date and tended to decrease progressively as hatching occurred later in the season (Table I). The abnormally low survival of grasshoppers in the June 20 treatment in 1956 is attributed to the cool, wet weather that followed hatching, when rainfall was recorded on seven of the first ten days. In 1957 and 1958 the percentage survival of the nymphs from the earliest-hatched groups was almost double that of nymphs from the latest-hatched group. Why higher survival should be associated with early hatching is not known. The reverse might be expected as temperatures generally rise from early May to July. It is possible that early foliage favoured survival as noted by Greenbank (1956) in the spruce budworm.

The early nymphal stage was the period during which the highest mortality occurred. Counts of survivors in the May 31 treatment in 1956 indicated that almost half the total mortality over the 54-day nymphal period took place during the first 24 hours. Similarly, in all treatments in 1958 the mortality rate was highest during the early nymphal period from hatching to the third instar; it decreased considerably during the latter part of the nymphal stage, was lowest during the first two months of adult life and then rose again in the latter part of the adult stage when old age was presumably taking its toll (Fig. 1).

Further evidence of the high mortality during the early nymphal stage was obtained from a laboratory study in the spring of 1958 using grasshoppers from the Delisle strain. The nymphs were reared for 18 days during which the total mortality amounted to 46 per cent; of this mortality almost three-quarters occurred during the first 48 hours. Where unfavourable weather, such as occurred in the June 20 treatment in 1956, is superimposed on this vulnerable

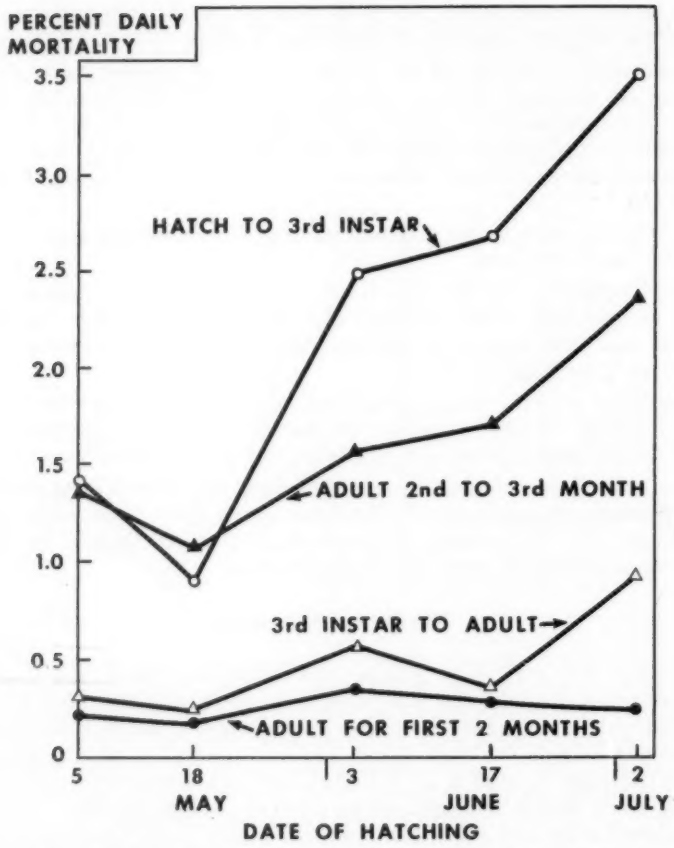

Fig. 1. Mean mortality rates of different stages of *M. bilituratus* hatched on various dates in 1958.

period a considerable increase in mortality may be expected. Further evidence of the effects of adverse weather conditions during the early nymphal stages was observed by Pickford (In preparation).

With the exception of the 1956 experiment there was a trend towards shortening of the nymphal period as hatching occurred later in the season (Table I); this trend is likely due to the progressively increasing temperatures as the season advanced. In the laboratory, Parker (1930) showed that the duration of the nymphal period varied inversely with the temperature, falling from 79 days at 22° C. to 23 days at 37° C. A comparison of the mean daily maximum temperatures for the months during which nymphal development was taking place indicates that temperatures generally increased as the summer season advanced during 1957 and 1958 but remained about the same in 1956 (Fig. 2).

Adults—The survival of grasshoppers during the first two months of the adult stage did not appear to be influenced by the date of hatching (Table I). No trends are apparent, but it should be noted that in 1957 and 1958 adult survival was consistently very high in all treatments. However, the survival of grass-

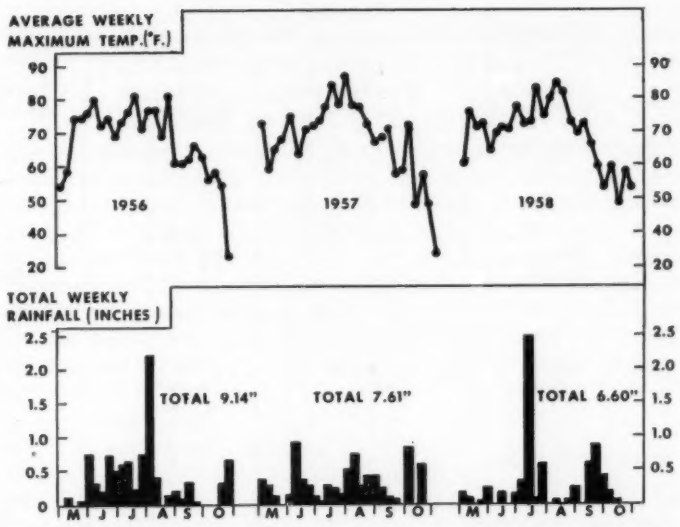

Fig. 2. Temperature and rainfall (May - Oct.) at Saskatoon, 1956-1958.

hoppers from the second to the third month of the adult stage in 1958 appeared to be influenced by the date of hatching in that survival tended to decrease as hatching dates became later (Fig. 1).

Survival of the adults did not appear unduly influenced by rapidly lowering temperatures in the fall. For example, the latest treatment in 1957, when counted on October 12, showed higher survival than any other treatment, notwithstanding cold weather from October 5 to 11 when daily minimum air temperatures were all below freezing and six inches of snow fell. Similar adult resistance to cold was noted in 1958; even after 21 successive days on which minimum air temperatures fell to freezing or lower there was still an appreciable number of grasshoppers surviving on November 10.

M. bilituratus appears to be relatively long-lived. In 1956 when field and laboratory rearing were combined the oldest survivor lived 188 days; in 1957 and 1958 when all rearing was done in the field cages, the oldest survivors lived 160 and 186 days respectively. Consequently, if this grasshopper it to take full advantage of its potentially long life-span, it must hatch early in the season.

Fecundity

Grasshoppers that hatched on the earliest dates in each experiment invariably laid the greatest number of eggs; those hatched in May laid about twice as many egg-pods per female as those hatched in July (Table II). In one cage in the May 5 treatment in 1958 the average fecundity was 22.7 egg-pods per female; this is the highest ever recorded for *M. bilituratus* reared in field cages and approximates that obtained in the laboratory by Pickford (1958). This fecundity is several times that obtained by Pfadt (1949), Smith *et al.* (1952) and Drake *et al.* (1945) and indicates that, under favourable conditions in the field, a large part of the reproductive potential of this grasshopper may be realized.

A progressive decline in fecundity generally occurred as dates of hatching became later; the somewhat lower than expected fecundity of the June 3 treatments in 1958 may be attributed to the slightly lower female survival in each of

TABLE II
Fecundity and hatchability of eggs laid by *M. bilituratus* hatched on various dates

Date hatched	Origin of grasshoppers	No. of egg-pods per female	No. of eggs per female-day	Percentage eggs hatching
May 31, 1956	Interior B.C.	6.2 (7.1)*	2.3	—
June 11		5.0 (8.7)	2.0	—
June 20		2.6 (8.1)	1.0	—
June 30		4.2 (9.5)	1.9	—
July 10		1.3 (7.5)	1.0	—
July 20		0.6 (9.6)	0.5	—
May 5, 1957	Delisle, Sask.	15.5	4.3	76.5
May 18		14.8	4.1	66.0
May 30		12.2	3.1	61.5
June 12		11.3	3.6	76.0
June 25		9.5	2.8	70.5
July 9		7.0	2.4	58.5
May 5, 1958	Delisle, Sask.	18.8	4.4	53.3
May 18		16.1	4.5	64.0
June 3		11.7	3.9	61.5
June 17		11.6	3.2	58.8
July 2		8.4	2.7	56.6
May 16, 1958	Lily Plain, Sask.	16.4	4.2	52.5
June 3		9.4	3.1	64.5
June 17		10.7	3.2	60.8
July 2		8.6	2.6	56.3

*Oviposition in Laboratory after conclusion of the field experiment.

these treatments. This decline in fecundity is attributed partly to the progressive shortening of the female adult life-span (Table I), and partly to the decline in the rate of oviposition or number of eggs laid per female-day (Table II).

Grasshopper fecundity was considerably higher during the summer than during the autumn. In 1958 the rates of oviposition in all treatments were two or three times greater from maturation to August 29 than from August 29 to the end of the experiment (Table III).

TABLE III
Oviposition during the summer (maturation to August 29) and during the fall (August 29 to end of experiment) by *M. bilituratus* hatched on various dates in 1953

Date hatched	Origin of grasshoppers	Maturation to Aug. 29			August 29 to end of Exp't.		
		No. of pods	Initial no. of females	No. of eggs per female-day	No. of pods	Initial no. of females	No. of eggs per female day
May 5	Delisle	947	60	5.03	180	48	2.06
May 16–18	Delisle	833	60	5.31	133	45	1.72
	Lily Plain	620	45	5.02	117	35	1.91
June 3	Delisle	492	60	4.39	207	48	2.37
	Lily Plain	445	60	3.41	118	45	1.61
June 17	Delisle	372	60	4.52	325	57	2.22
	Lily Plain	396	60	4.33	245	55	2.09
July 2	Delisle	113	45	3.69	257	37	2.63
	Lily Plain	207	60	3.89	303	56	2.03

More detailed data on grasshopper fecundity from the May 5 treatment in 1958 indicated that late June to early August was the most favourable period for oviposition. The number of eggs laid per female-day by grasshoppers during the different periods were:

June 20 - August 11	6.12
August 11 - August 29	4.52
August 29 - September 18	4.26
September 18 - October 1	1.85
October 1 - October 27	0.43

This decline in fecundity as the season advanced was not a result of aging of the females as may be seen in Table III; here the rate of oviposition from August 29 to the end of the experiment was practically the same in all treatments whether females were old or young. This reduced fecundity is attributed to declining temperatures as the season advanced (Fig. 2); this is supported by data from the May 31 treatment in 1956 in which the oviposition rate, after dropping by one-third from summer to autumn, rose again sharply when the grasshoppers were removed to the higher laboratory rearing temperatures at the conclusion of the field experiment on October 22. The number of eggs laid per female-day during the different periods were:

Maturation - August 15	3.60
August 15 - October 22	1.20
October 22 - December 5 (Lab.)	5.88

Also, Parker (1930) recovered six to eight egg-pods per female of *M. bilituratus* reared at temperatures ranging from 27° to 37° C., but only 0.4 egg-pods per female at 22° C.

The size of egg-pods laid by females from these experiments did not appear to be influenced by the date of hatching; differences between numbers of eggs per pod were generally not significant. However, there were significant differences in the number of eggs in pods laid by grasshoppers originating from the different populations; for example, those from British Columbia laid egg-pods containing an average of 23.8 eggs while those from Delisle and Lily Plain in Saskatchewan contained 21.9 and 21.4 eggs, respectively.

Although egg-laying was considerably reduced in 1958 during the late autumn when temperatures declined, appreciable numbers of ovipositing females were observed during the month of October when air temperatures only once exceeded 70° F. The latest observed egg-laying occurred on October 27 when the maximum temperature was 49° F. This is in contrast to the report by Parker (1930) that oviposition did not occur at air temperatures below 69° F.

The hatchability of eggs laid by females from the various treatments did not appear to be affected by the dates on which grasshoppers were hatched (Table II). The percentage hatching varied from 58.5 to 76.5 in 1957 and from 52.5 to 64.5 in 1958; however, differences among treatments were not significant at the five per cent level. Eggs from the earliest treatments hatched up to seven days sooner than those from later treatments, presumably due to the more advanced development of the embryos.

Population Growth

The population growth indices, which indicate the rise in cage populations from nymph to egg, were invariably highest in the earliest-hatched treatments and tended to decline progressively as grasshoppers were hatched later in the season (Fig. 3). In 1956 this index declined from 41.4 in the earliest treatment to 3.8 in the latest; similarly, in 1957 it declined from 90.5 to 20.8 and in 1958 from 152.2 to 31.0 in one experiment and from 140.5 to 44.1 in the other.

It should also be noted that the population growth indices have tended to increase with each succeeding year. One possible explanation for this is that

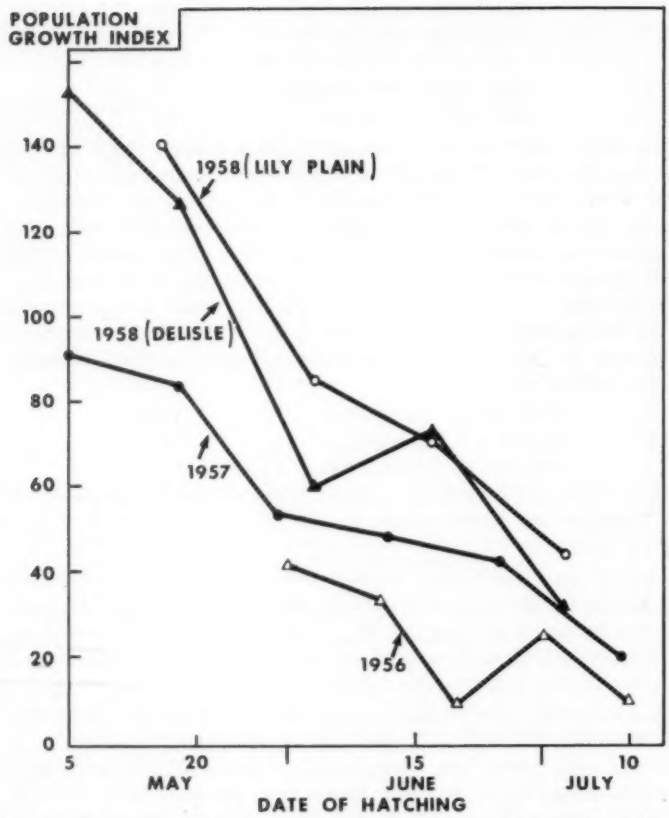

Fig. 3. Population growth indices of *M. bilituratus* hatched on various dates over a three-year period.

weather conditions became increasingly more favourable for grasshoppers, that is warmer and drier, with each succeeding year (Fig. 2). Numerous authors, including Parker (1955), Brett (1947), Putnam (1954) and Criddle (1917), have linked grasshopper population build-ups with drouth conditions. One indication of the suitability of conditions for grasshopper development during 1958 was the appearance of a second generation in several of the cages; this is the first recorded instance of a second generation of grasshoppers in Saskatchewan.

Unpublished records at the Saskatoon Research Station have shown that field populations of *M. bilituratus* during the same period in Saskatchewan have also increased with each succeeding year; the field population index, which is based on area infested and degree of infestation, showed a ninefold increase from 1956 to 1957 and was more than doubled again in 1958.

Summary and Conclusions

Field cage experiments carried out from 1956 to 1958, in which *Melanoplus bilituratus* was reared from hatching to the end of the season, demonstrated the close relationship of the date on which grasshoppers hatch to population growth; those hatched in May showed population increases up to ten times those hatched

seven to nine weeks later in July. Population growth was dependent primarily on nymphal and adult survival and adult longevity and fecundity.

Nymphal survival was consistently higher in grasshoppers that hatched earliest in the season. However the most vulnerable stage in the whole life cycle appeared to be the very early nymphal stage. When unfavourable weather conditions occurred during this early nymphal period grasshopper populations were greatly reduced.

Adult survival during the first two months following the last moult did not appear to be influenced by the date of hatching; during this period the mortality rate was lower than that during any other stage; in addition, the adults proved able to withstand fairly extended periods of cool weather during the fall.

Fecundity was invariably highest where hatching occurred early in the season; grasshoppers in one cage of the earliest-hatched group in 1958 averaged 22.7 egg-pods per female, the highest egg production ever recorded for *M. bilituratus* reared under field conditions. This high fecundity was partly due to the greater adult longevity and to a higher rate of oviposition. The rate of oviposition, in terms of the number of eggs produced per female-day, was highest about mid-summer when temperatures were at their maximum. The decline in the rate of oviposition towards the end of the season was due mainly to declining temperatures and not to old age of the females. However, females were still able to lay almost to the end of October even though temperatures had fallen considerably.

The date of hatching appeared to have no effect on the size of egg-pods or the hatchability of the eggs laid.

Successive increases in the population growth indices of grasshoppers reared in field cages occurred from 1956 to 1958. Similar increases over the same period occurred in field populations of this species throughout Saskatchewan. It is suggested that warmer and drier weather was primarily responsible for these increases.

Acknowledgments

The author acknowledges the helpful advice and criticism of L. G. Putnam. Meteorological data were obtained from the Prairie Regional Station of the Division of Building Research, National Research Council, Saskatoon.

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Life History and Behavior of the Bramble Leafhopper, *Ribautiana tenerrima* (H.-S.) (Homoptera: Cicadellidae)[1]

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Since 1947, when the bramble leafhopper, *Ribautiana tenerrima* (H.-S.) (*rubi* Hardy, *misella* Boh.), was first reported in North America near Victoria, B.C., it has become a serious pest in cane fruit plantings on southern Vancouver Island and the lower Fraser Valley. Both nymphs and adults suck the sap from the leaves, producing a white stippling on the upper surfaces (Fig. 1). In a dry season a severe infestation causes many leaves to become curled and appear burned. The canes lack vigor and the size of the fruit is reduced. This is a report on a study of the life history and behavior of the species conducted at Victoria from 1953 to 1957.

History and Distribution

A native of Europe, the species was first described from Germany in 1834 under the name *Typhlocyba tenerrima* by Herrich-Schäffer. It is widely distributed in Europe, being recorded from Sweden to Italy and westward (Melichar, 1896; McAtee, 1926; Ribaut, 1936; Wagner, 1939; Ossiannilsson, 1946-7; Dlabola, 1954). In England, Hardy (1850) and Edwards (1896) recorded the species; Wilson (1947) reported it of economic importance. In North America, it was listed erroneously by Gillette (1896) and Van Duzee (1947), the first authentic report being made by Andison (1950) from specimens collected on Vancouver Island near Victoria and at Cowichan Bay, and on Lulu Island in the lower Fraser Valley of British Columbia. Since then it has spread throughout Vancouver Island, being found as far north as Sayward (225 miles north of Victoria) on the east coast and at Port Alberni on the west coast. It also occurs at Vesuvius Bay on Salt Spring Island, one of the larger islands between Vancouver Island and the mainland, and has spread throughout the lower Fraser Valley as far east as Hope, B.C.

Hosts

The principal hosts of *R. tenerrima* are a group of closely related cane fruit plants, *Rubus* spp., sometimes referred to as brambles. All stages of the leafhopper were observed on Himalaya blackberry, *R. procerus* Muell.; cutleaf blackberry, *R. lacineatus* Willd.; red raspberry, *R. ideaus* L., var. Taylor, Viking; loganberry, *R. loganobaccus* Bailey, and boysenberry, *R.* spp. Thimbleberry, *R. parviflоris* Nutt., supported small numbers of nymphs and adults. Adults were often found feeding on strawberry plants, *Fragaria* sp., variety British

[1]From a thesis submitted in partial fulfilment of the requirements for the M.S. degree, Oregon State College, 1956.

Sovereign, adjacent to cane fruit plantings, but nymphs only occasionally. Many specimens commenced their life cycle on one *Rubus* host and completed it on another.

Methods

Sampling.—Loganberry foliage was sampled to determine when adults and nymphs occurred and to estimate their peaks of emergence and duration in the field.

To sample adults, 10 alternate plants, in a row selected at random, were swept on the north and south sides of the row at intervals of about 10 days commencing the last week in May. Because of the thorny nature of the host, sweeping was best accomplished by placing a light nylon net (15 inches in diameter and without a handle) over a group of laterals along the top wire supporting the canes, and shaking the leaves inside the net. The net was then removed and four sweeps made back and forth near the bush to catch adults that flew up. The contents of the net were emptied into a 10-pound paper bag containing capsules of calcium cyanide and examined later in the laboratory.

To sample nymphs, 20 laterals (five to seven leaves per lateral) on the top wire of a row of canes selected at random, were examined at about weekly intervals commencing the first week in May. In May and June, while the first-generation nymphs were developing, only laterals with stippled leaves were examined, as this symptom usually indicated the presence of nymphs on the undersides. From August to October, while second-generation nymphs were developing, laterals were selected at random as stippled leaves then may have been caused by the first generation.

Rearing.—The fecundity and pre-oviposition periods of the adults, the incubation periods of the eggs, and the durations of nymphal instars were determined in the insectary. Fecundity was determined by caging pairs of first-generation adults with potted loganberry plants (Fig. 2) and recording the number of nymphs that resulted two months later. The pre-oviposition period of first-generation adults and the incubation period of their eggs were determined by placing four series, each consisting of five pairs that transformed on the same date, in cylindrical plastic cages containing leaves held in a vial of water (Fig. 3) for three to nine days and then transferring each pair each day for 30 days to a bivalve cage (Fig. 6) enclosing leaves and petioles of small loganberry plants. A few adults escaped or died during transfer but the procedure did not appear to affect egg-laying by the survivors. After each transfer, the bivalve cage was removed, the leaves were labelled showing the date of exposure to females, and tanglefoot barriers placed around the canes in a narrow band above and below each petiole. The plants were then placed in a large cheesecloth cage to prevent further infestation. The foliage was examined daily for the presence of nymphs and the date of hatch was recorded. The pre-oviposition period of second-generation adults was determined by placing pairs that transformed on the same day in two cages containing single pairs and in three cages containing two or three pairs for ten days as before, and then transferring each group daily to a new leaf and vial within a cylindrical plastic cage (Fig. 3). The foliage was examined daily for eggs.

The durations of first-generation nymphal instars were determined by cutting 12-inch lengths from canes that had overwintered in the field and placing them with their bases in jars of water in early June. The canes were examined daily and newly emerged, first-generation nymphs were transferred to the leaves of small potted loganberries and confined in small plastic clip cages (Figs. 4, 5)

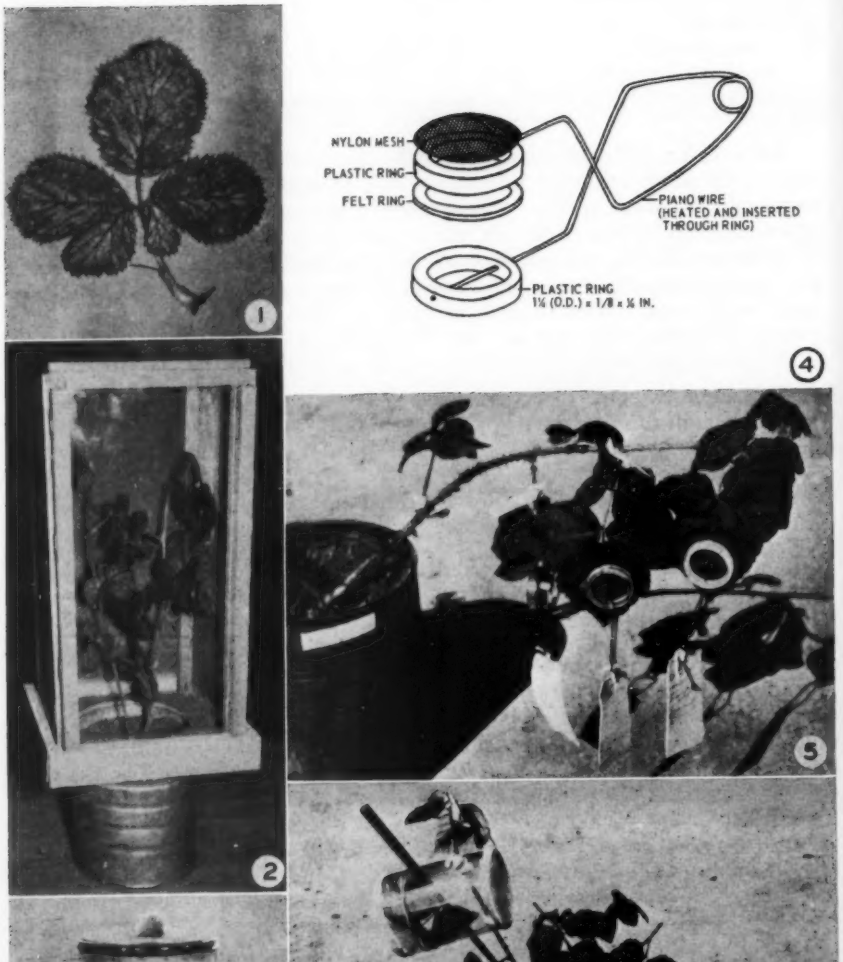


Fig. 1. Blackberry leaf injured by *Ribautiana tenerrima*. Figs. 2-6. Cages used in life history studies. 2, Screen cage with glass front over potted loganberry plant. 3, Cylindrical plastic cage. 4, 5, Plastic clip cages. 6, Bi-valve cage.

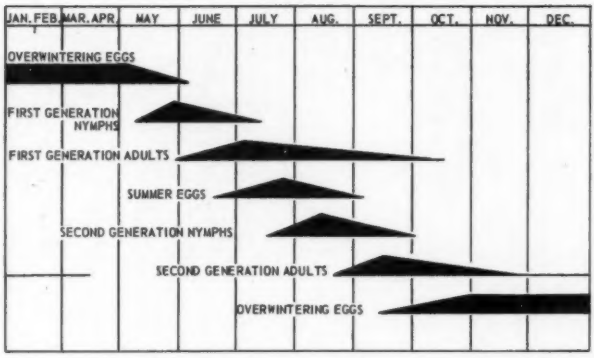


Fig. 7. Life history of *R. tenerrima.*

similar to those developed by Walrave (1951). Daily observations were made on the development of the nymphs. The durations for second-generation nymphs were determined by collecting first-generation adults in the field during June and caging them with potted loganberry plants in the insectary. They oviposited in the foliage, which was then examined daily for newly hatched, second-generation nymphs. These nymphs were transferred singly to clip cages (Fig. 5) and observed daily for development to adults.

Egg

Description.—The newly laid egg is translucent and hyaline, later becoming opaque. It is elongate, slightly curved, and narrow at one end. The average length is 0.76 mm., the width 0.22 mm. The chorion is smooth and lacks reticulation. As the embryo forms, a vesicle, which is opaque and is filled with fluid, develops at the narrow, anterior end of the egg between the embryonic membrane and the head of the nymph (Fig. 8). As the embryo approaches maturity, the red eyes, segmentation, and appendages of the future nymphs may be readily seen through the embryonic membrane, which is slightly opaque beneath the transparent chorion.

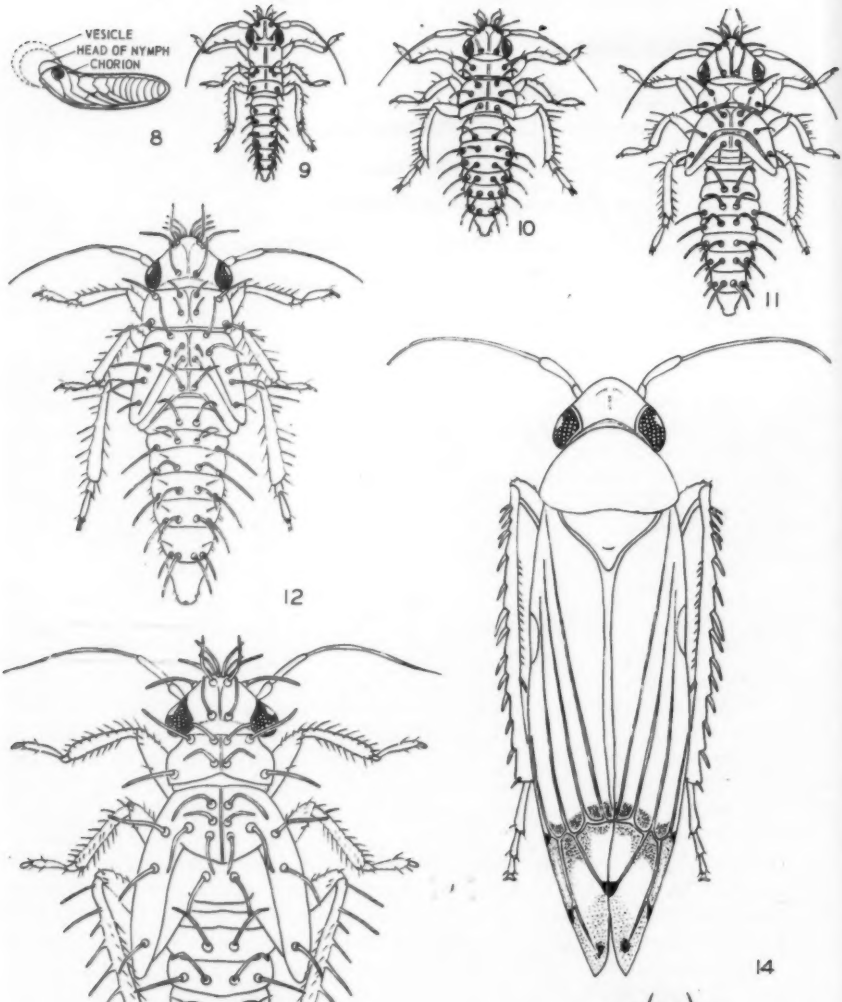
Occurrence.—Eggs of the first generation (summer eggs) are laid in the midribs and petioles of the leaves and in the laterals of the fruiting canes. They were laid from late June until early September, most being laid during July.

Eggs of the second generation (overwintering eggs) are occasionally laid in the leaves but most are laid just beneath the bark of the new canes. They are laid either lengthwise or across the cane and are distributed over its entire length except for two or three feet at the tip. Under the microscope the oviposition sites appear as small blisters in the bark with a puncture at the end of each blister. No eggs were found in the old canes in the late fall. The eggs were laid from late September until early November and overwintered until the following May (Fig. 7).

Incubation.—The incubation period of eggs laid by first-generation females averaged 28 days and ranged from 23 to 35 days. Eggs of the first generation laid during the latter part of June required incubation periods approaching the maximum; those laid in July required the minimum.

Nymph

Description.—There are five nymphal instars (Figs. 9-13). Newly emerged, first-instar nymphs are hyaline, later becoming opaque, with dark-red eyes and



Figs. 8-14. *Ribautiana tenerrima* (H.-S.). 8, Egg hatching. 9-13, Dorsal aspect of instars 1-5. 14, Dorsal aspect of adult. Fig. 15. *Edwardsiana rosae* (L.)—dorsal aspect of fifth instar.

TABLE I.
Average measurements (mm.) and ranges (in parentheses), of 20 specimens of each instar of two species of leafhoppers

Stage	Diameter of head[1]		Length[2]	
	R. tenerrima	*E. rosae*	*R. tenerrima*	*E. rosae*
Nymphs				
First instar	.25 (.25–.25)	.27 (.25–.29)	.94 (.79–1.04)	.95 (.72–1.12)
Second instar	.32 (.31–.32)	.35 (.32–.36)	1.15 (.90–1.30)	1.22 (1.04–1.33)
Third instar	.40 (.40–.43)	.43 (.40–.43)	1.54 (1.37–1.66)	1.62 (1.37–1.76)
Fourth instar	.50 (.49–.52)	.54 (.50–.58)	2.16 (1.95–2.40)	2.83 (2.38–3.08)
Fifth instar				
Male	.60 (.58–.61)	.67 (.63–.71)	2.61 (2.31–2.94)	2.69 (2.38–3.08)
Female	.63 (.61–.65)	.69 (.65–.71)	2.78 (2.38–2.94)	2.83 (2.38–3.08)
Adults				
Male	.58 (.56–.58)	.66 (.61–.68)	3.26 (3.15–3.45)	3.75 (3.60–3.90)
Female	.60 (.58–.61)	.69 (.65–.71)	3.49 (3.30–3.60)	4.03 (3.75–4.20)

[1]Across compound eyes.
[2]Nymph: total length of head, thorax and abdomen; adult: lenght from vertex to tips of wings.

prominent antennae. Nymphs of later instars are similar to one another in appearance except for an increase in size with each moult and the development of wing pads in the fourth and fifth instars. These nymphs are pale, the head is rounded or slightly conical, and the eyes are colorless or have the centers of some facets an indistinct purple. The robust, hyaline hairs are very conspicuous, being bent at the tips and arranged in a definite pattern (Fig. 13). The widths of the head capsules and lengths of 20 specimens of each instar are recorded in Table I.

The plate of the male genitalia and the spear-shaped ovipositor of the female are apparent in the fourth and fifth instars (Fig. 16, 17).

The main external characters distinguishing the nymphs from those of the rose leafhopper, *Edwardsiana rosae* (L.) (Fig. 15), which is often found on the same hosts with *R. tenerrima* (Fig. 13) in the coastal areas of British Columbia, are as follows. In *tenerrima*, the vertex of the head is rounded, almost conical, and the hairs of the body are conspicuous, robust, hyaline, and bent at the tips. In *rosae*, the vertex is truncate with the sides in front of the eyes concave; the hairs are less conspicuous, finer, darker, and slightly curved. The head capsule of *rosae* is slightly wider than that of *tenerrima* (Table I).

Occurrence.—First-generation nymphs occur on the undersides of the leaves of the fruiting canes. In the field, they commenced to hatch during the first two weeks of May, when the laterals of the fruiting canes were four to eight inches long. They reached their peak in late May, when as many as 20 nymphs per leaf occurred, and continued until early July.

Second-generation nymphs occur on the undersides of the leaves of both old and new canes. They commenced to hatch during the last two weeks of July, when loganberry picking was in progress. They reached their peak about mid-August and continued until early October (Fig. 7).

In the insectary the nymphs usually hatched during the morning, when temperatures were between 53 and 68° F.

Hatching.—When ready to emerge, the mature embryo is oriented within the egg membranes with its head just below the puncture made in the plant tissue during oviposition. The vesicle is expanded by fluid pressure to widen the ovi-

position puncture, split the chorion, and burst the embryonic membrane (Fig. 8). The nymph then commences to slide out of the egg folds and to emerge through the oviposition puncture. It soon stands erect with only the hind legs and the tip of the abdomen in the egg folds. While the nymph is in this position the hairs spring up and the appendages and antennae are flexed and held away from the head and body. The nymph then bends down to the cane or petiole, and by wriggling and using its fore legs it pulls itself free of the egg folds, which are left in the egg chamber. The nymph can be active the moment it is free of the egg folds but usually it moves an inch or so away and rests a moment before searching for a leaf on which to feed.

Feeding.—The nymphs feed almost entirely on the undersides of the leaves, and develop equally well on foliage of the old and new canes. They appear to feed continually except during ecdysis.

Moulting.—Transformation from nymph to adult usually takes place on the undersides of the leaves and requires about 30 minutes. The procedure is similar to that of the rose leafhopper, *E. rosae,* as described by Childs (1939).

Durations of Instars.—The average numbers of days in the various instars for the first-generation females and the second-generation males and females were:

	First	Second	Third	Fourth	Fifth	Total
Female.....	6.6	6.2	6.2	7.0	9.8	35.8
Male.....	5.2	5.6	6.1	6.5	9.9	33.3
Female.....	5.4	5.4	6.7	7.4	11.7	36.6

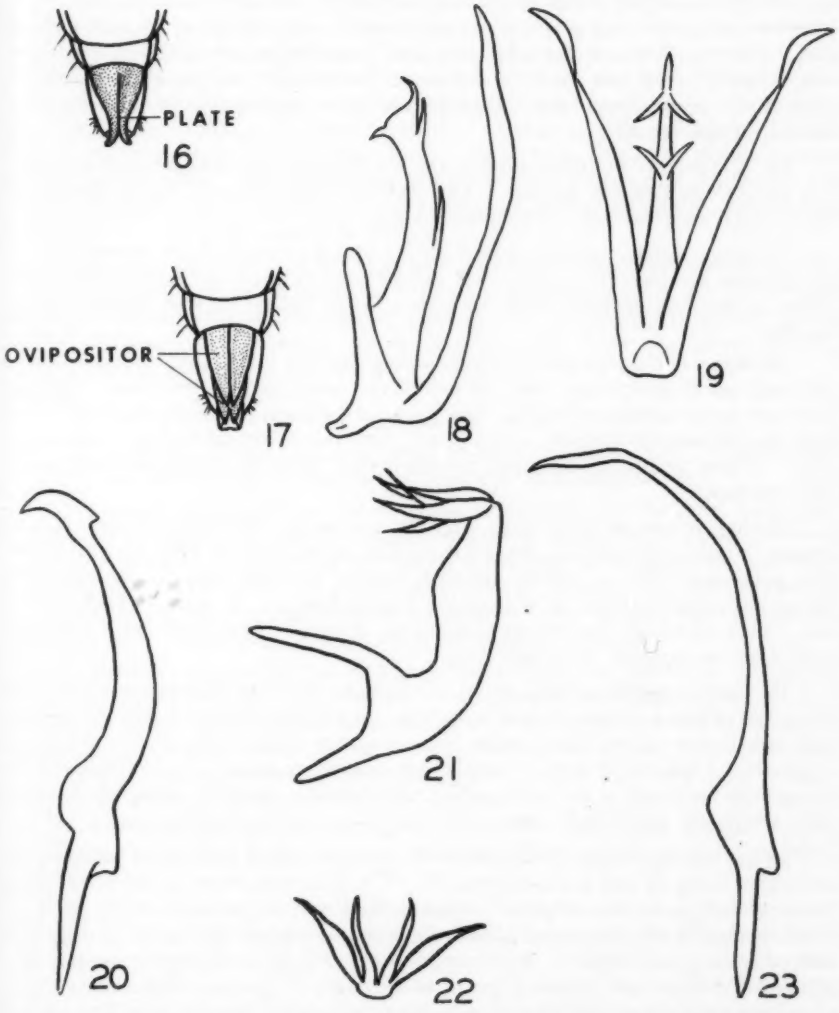
Individual records of 80 nymphs indicated that when nymphs were slow to complete one instar they grew more quickly in another, resulting in nearly uniform total developmental periods.

Adult

Description.—Specimens of adults (Fig. 14) collected on Vancouver Island were described by Christian (1953) and Beirne (1956). The style and aedeagus are shown in Figs. 18 to 20, distinguishing the adults from those of the rose leafhopper, *E. rosae* (Figs. 21-23). Measurements are recorded in Table I.

Occurrence.—First-generation adults occur on the undersides of the leaves of the fruiting canes. They sometimes appeared during the last week of May, but usually appeared during the first two weeks of June, when loganberries were in blossom. They reached their peak in early July and some specimens lived until mid-October, overlapping the second generation.

Second-generation adults occur on the undersides of the leaves of both old and new canes. They commenced to appear during the last two weeks of August, when harvest was over but before the old canes had been removed. They reached their peak about mid-September and continued until late November, a few specimens overwintering if the winter was mild. In 1955, a few adults survived minimum temperatures of 12.5° F. and were taken on logenberry as late as January 29 of the following year. In 1956, adults were observed on blackberry (variety Ollalie) as late as January 23 of the following year but failed to survive minimum temperatures of 16.8° F. that occurred a few days later.



Figs. 16-20. *Ribautiana tenerrima* (H.-S.). 16, 17, Ventral aspect of genitalia of fifth instar ♂ and ♀. 18, 19, Left lateral and ventral aspects of aedaegus. 20, Left lateral aspect of style.

Figs. 21-23. *Edwardsiana rosae* (L.). 21, Left lateral aspect of aedeagus. 22, Ventral aspect of apical processes of aedeagus. 23, Left lateral aspect of style.

The winter of 1957-58 was exceptionally mild and adults were taken on March 4, 1958 (Fig. 7).

Sex Ratio.—The males appear in the field about one week before the females. In collections made at about 10-day intervals from June to September, 1957, male adults were about twice as numerous as females at the beginning of each generation. The number of males then decreased until the mid-point of each generation, when the ratio was about 1:1. Females became increasingly abundant thereafter, until in the latter part of each generation practically all the specimens collected were females.

Of 522 fourth- and fifth-instar nymphs collected from August to September, 274 were males and 248 females. This indicates that within a single generation the average ratio of males to females is about 1:1.

Feeding.—Adults sometimes feed on the upper surfaces of the leaves, and on the petioles and succulent canes, but usually they feed on the undersides of the leaves in the same manner as the nymphs. They appear to feed mostly during the day.

Mating.—The leafhoppers usually mate on the undersides of the leaves although occasionally they mate on top of the leaves and on the canes. Mating pairs are most evident during the morning and evening, or during the day when dull, humid weather prevails. Many pairs mate just before or during a shower of rain. When copulating pairs are disturbed they often fly to another leaf while still attached.

Mating occurs six to 15 days after the females transform to adults. Before mating, a male and a female stand side by side, apparently in some sort of courtship procedure (Oman, 1949). During mating the male and female assume a tail-to-tail position similar to that of the rose leafhopper, *E. rosae* (Childs, 1918), and remain in coitus for one to two hours. Females often mate with a second male after an interval of several days.

Oviposition.—Before oviposition the female becomes sluggish and searches along the petioles, laterals, or canes with her stylets, apparently testing the texture and succulence of the plant tissue for a suitable place to oviposit. Also, she often inserts the tip of her ovipositor into the plant tissue several times before completely inserting it and ovipositing. Oviposition requires about 10 minutes, after which she rests briefly before searching for more egg-laying sites.

In the insectary seven first-generation females laid an average of 40 eggs, the maximum being 55 and the minimum 29. The pre-oviposition period of the four series of first-generation adults averaged 20 days and ranged from 10 to 37 days, whereas that of the five series of second-generation adults averaged 22 days and ranged from 15 to 30 days. The oviposition period of the first-generation adults averaged 20 days and ranged from 12 to 27 days. Eggs were laid almost every day during the oviposition period, and the females died shortly after they ceased laying.

Longevity.—The females appeared to live longer than the males and the first and second generations overlapped. During fecundity studies of first-generation adults, when pairs were placed in cages and undisturbed, nine females lived from 40 to 80 days and averaged 55 days, whereas six males lived 40 to 60 days and averaged 50 days. During pre-oviposition studies of second-generation adults, when pairs were transferred daily to new foliage, six females lived 23 to 50 days and averaged 33 days, whereas 10 males lived from 10 to 23 days and averaged 18. Handling undoubtedly affected their longevity but throughout the experiment

the males had to be continuously replaced while the females persisted. Also, in the field, females were about twice as numerous as males in the latter part of each generation.

Parasites and Predators.—Several adult leafhoppers collected in the field were parasitized by a small, pale, legless grub that emerged from the posterior end of the adult. Attempts to rear this grub were not successful. Spiders preyed on the adults. Dr. W. Gertsch, American Museum of Natural History, New York, determined one species as *Metaphidippus aeneolus* Curtis, and placed a second species in the subfamily Erigoninae. Species of *Metaphidippus* are common diurnal jumping spiders that do not often spin webs and usually wander about considerably. The Erigoninae are a sedentary group that spin small webs on the ground or on vegetation. In the field, the leafhopper adults often become ensnared in webs spun among the leaves.

A number of overwintering eggs in the bramble canes were parasitized by a tiny, fringe-winged hymenopterous parasite determined by Dr. O. Peck, Entomology Division, Ottawa, as *Anaphes* sp. of the subfamily Mymarinae (fairy-flies). This parasite develops within the egg, and upon emergence leaves a characteristic "shot hole" in the bark of the canes.

Summary

R. tenerrima, which was first found in North America near Victoria, B.C., in 1947, has since become a serious pest on cane fruits (*Rubus* sp.).

Characters distinguishing the nymphs from those of the rose leafhopper, *Edwardsiana rosae* (L.), which is often found on the same hosts with *R. tenerrima,* were determined. In *tenerrima* the vertex of the head is rounded, almost conical, and the hairs of the body are conspicuous, robust, hyaline, and bent at the tips. In *rosae* the vertex is truncate with the sides in front of the eyes concave; the hairs are less conspicuous, finer, darker, and slightly curved.

There are two generations of *R. tenerrima* each year. Most of the population overwinters as eggs in the canes. First-generation nymphs hatch in early May, and adults appear in late May and early June. Eggs are laid in the leaves, petioles, and lateral stems of the fruiting canes from late June until early September. Second-generation nymphs appear in late July and early August, the adults during late August and early September. Eggs are laid in the new canes in late September and throughout October. The adult females tend to outlive the males and sometimes live until the following March if the winter is mild.

Mating occurs on the undersides of the leaves six to 15 days after transformation. The pre-oviposition period is about 20 days, the incubation period of the summer eggs 28 days. The average number of eggs laid by seven first-generation adults was 40. Nymphs pass through five instars, increasing in length from 0.94 to 2.78 mm. First-generation female nymphs require an average of 36 days to complete their development; second-generation males require 33 days, the females 37 days. Spiders prey on the adults; mymarids (*Anaphes* sp.) parasitize the eggs.

Acknowledgments

I wish to thank Mr. H. Andison, of the Victoria laboratory, who suggested this study and contributed Fig. 1. I also wish to acknowledge the helpful criticism of Mr. W. T. Cram, of the Victoria laboratory, and Dr. C. H. Martin, Department of Entomology, Oregon State College, Corvallis, Oregon.

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Taxonomy of Cocoons and Puparia, and their Contents, of Canadian Parasites of *Neodiprion sertifer* (Geoff.) (Hymenoptera: Diprionidae)

By THELMA FINLAYSON[1]

INTRODUCTION

This is the first of a planned series of papers on the taxonomy of the cocoons and puparia, cast larval skins, and other remains of parasitic Hymenoptera and Diptera that are found in or near the remains of parasitized hosts after the parasites have emerged. The study is based, at least initially, on the host species so that the keys and descriptions may be of use to those who work on the host species as such and who wish to name parasite remains they encounter. The parasites of Diprionidae will be dealt with first, because of the economic significance of these sawflies. The present paper deals with the known Canadian parasites of the European pine sawfly, *Neodiprion sertifer* (Geoff.), and includes descriptions of the structures that are of taxonomic significance and of the methods used in their study; these descriptions will be in general applicable to the species to be discussed in subsequent papers.

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MATERIALS AND METHODS

The material consisted of parasite cocoons or puparia that could be positively associated with the specimens they produced; identifications of the latter were made or confirmed by specialists. All of the material was from the Entomology Research Institute for Biological Control, Belleville, and the Canadian National Collection in the Entomology Research Institute, Ottawa.

For examination, the cast larval skins are removed from the cocoon, softened by soaking in 10 per cent potassium hydroxide at room temperature for several hours, or for about ten minutes at about 140-150° F. Then the skin is washed in water, immersed for 30 seconds in a weak solution of carbol fuchsin stain, washed again in water, and mounted on a microscope slide in de Faure's solution.

CHARACTERS OF TAXONOMIC SIGNIFICANCE

The following characters were found to be of taxonomic value: the size, shape, and position of the exit hole in the host cocoon; the presence or absence and the size, shape, colour, and texture of the parasite cocoon, and whether the parasite is solitary or gregarious; the situation in the host of the remains, and whether they are attached or free; and the morphology of the cephalic structures and spiracles of the last larval instar of the parasite. The cephalic structures and spiracles provide the most useful characters for separating the species, although these are usually used in combination with the other characters.

Hymenoptera

The chief taxonomic characteristics of parasitic Hymenoptera are in the cephalic structure of the cast skin of the final-instar larva. Certain structures, such as the tentorium, that are present in the living larva are absent from the cast skin and consequently are omitted from the following keys, descriptions, and figures.

The cephalic structures of the final-instar larva of parasitic Hymenoptera were described by Beirne (1941), Morris, Cameron, and Jepson (1937), Short (1952), Thorpe (1930), and Vance and Smith (1933). The terminology used here largely follows that of Short, who based his on Snodgrass (1928, 1935, 1947, 1950), and of Beirne, who adapted his from Vance and Smith.

The authors mentioned above applied different names to the same structures. The following is a list of terms used in the present paper (see also Fig. 1) with the terms used by those authors listed where they differ:

epistoma: labral strut of Thorpe;

hypostoma: mandibular strut of Thorpe;

inferior mandibular process: inferior pleurostomal ramus of Beirne and of Vance and Smith; inferior mandibular strut of Morris et al.; posterior pleurostomal process of Short; mandibular strut of Thorpe;

labial palp: labial sensillae of Thorpe;

labial sclerite: labial sclerome of Beirne; labial ring of Morris et al. and of Thorpe; and labiostipital sclerome of Vance and Smith;

labral sclerite: labral sclerome of Beirne; clypeal arch of Morris et al.; unnamed by Thorpe and by Vance and Smith;

lacinial sclerite: unnamed by any of the other authors;

maxillary palp: maxillary sensillae of Thorpe;

pleurostoma: labral strut of Thorpe;

prelabial sclerite: ligular sclerome of Beirne and of Vance and Smith; ligula of Morris et al.; unnamed by Thorpe;

sclerotic spur of hypostoma: stipital sclerome of Beirne and of Vance and Smith; maxillary strut of Morris et al. and of Thorpe;

silk press: silk duct of Beirne and of Vance and Smith; salivary opening of Morris et al.; unnamed by Thorpe;

stipital sclerite: maxillary sclerome of Beirne and of Vance and Smith; labial strut of Morris et al. and of Thorpe;

superior mandibular process: superior pleurostomal ramus of Beirne and of Vance and Smith; superior mandibular strut of Morris et al.; anterior pleurostomal process of Short; and labral strut of Thorpe;

suspensorial sclerite of the hypopharynx: pharyngeal trough of Thorpe; unnamed by Beirne, Morris et al., and Vance and Smith.

The following are notes on the characters used in the keys, descriptions, and illustrations. The shapes of all these structures are of taxonomic significance.

The antennae are situated dorso-laterally to the cephalic armature within a circular area, the antennal socket. They vary in size and shape and are a useful character for separating some species.

Dorsally the epistomal arch, which may or may not be complete, and laterally the pleurostomata separate the clypeus from the front of the face, or frons. According to Short, the labral sclerite defines the limits of the labrum. This latter usually bears sensillae and setae, and may extend over part or the whole of the mandibles. The hypostomata extend laterally on either side from the ventral portions of the pleurostomata. Each pleurostoma elongates into a dorsal process that articulates with the mandibles. This dorsal, or superior, mandibular process consists of a single strut, though there is some indication that in *Aptesis* and Ichneumonid sp. A. it may be bi-lobed, the two lobes joined by a thin layer of sclerotized tissue. The lower, or inferior, mandibular process may possess one or more struts. The present writer agrees with Beirne that this may not be a part of the pleurostoma, but rather a hypostomal structure. It is for this reason that the term inferior mandibular process is used for it. To keep the terminology consistent, the dorsal process is called the superior mandibular process.

The mandibles vary in size and shape and possess one or two rows of teeth or none. Beirne stated that in general ectoparasites have mandibles with toothed blades and endoparasites have mandibles without teeth on the blades.

According to Short, the hypopharynx is fused with the maxillae and labium to form an under-lip complex, and part of the hypopharynx has become enclosed within the head cavity. The suspensorial sclerite of the hypopharynx is a thickening to which are attached hypopharyngeal and silk-press muscles. In some species (e.g. *Exenterus* spp.) the roof of the hypopharynx is covered with minute teeth.

The maxillae lie ventral to the hypostomata and each consists of a cardo, stipes, and lacinial lobe. The sclerotic bar that extends from the cardo along the posterior edge of the maxilla is stated by Short to be homologous with the sclerotized part of the stipes in more primitive insects, and is therefore called by him the stipital sclerite. The maxillary palpi are apparent as flat discs with one or more sensoria.

A sclerite extends across the stipes from each hypostoma to the stipital sclerite, and is called the sclerotic spur of the hypostoma, or hypostomal spur, by both Snodgrass (1935), and Short.

In some species, pointed processes extend antero-medially into the lacinial lobe of the maxilla from the point of junction of each hypostomal spur with the hypostoma. These have been called the lacinial sclerites. They are shown by Morris, Cameron, and Jepson in their illustrations of several species, and by Beirne in his illustration of *Exenterus adspersus* Htg.

The labium consists of the prelabium and the postlabium. Snodgrass (1935) and Short regarded the labial sclerite as a marginal sclerotization of the prelabium, and the prelabium as that area below the orifice of the silk press and within the labial sclerite. Short considered that the postlabium is that part of the labium posterior to the stipital and labial sclerites. The labial sclerite is a ring, usually broken dorsally and occasionally ventrally. The dorsal arms of this sclerite are usually thickened and may sometimes be twisted in relation to the ventral part. The labial palpi appear as flat discs on the prelabium, each with one or more sensoria.

The silk press, which is a thickening of the wall of the silk glands, is clearly visible in most species between the dorsal arms of the labial sclerite. A Y- or U-shaped sclerite ventral to the silk press is present in some species on the prelabium and was named the prelabial sclerite by Short.

The spiracles are fairly characteristic for each species, and may be used in combination with other characters for specific identifications. Each consists of a large, roundish atrium, usually containing reticulations of varying numbers and position; the atrium is joined to a stalk, sometimes annulated, that varies in length with the species and that leads into the thick-walled closing apparatus. The spiracles figured and described were not chosen from one particular segment, as no significant differences were apparent between those of different segments of any species.

Diptera

The last instar larvae of some Bombyliidae were described by Berg (1940) and by Brooks (1952), and the terminology adopted here for the head of the last instar larva is that used by those authors. As only one bee-fly, *Hemipenthes sinuosa* (Wied.), parasitizes *N. sertifer*, the discussion of the parts is given with the description of that species.

The nomenclature used in the descriptions of the buccopharyngeal armature of last stage larvae of the Tachinidae follows that used by Thompson (1928). The structure (Fig. 21) consists of two anterior mandibular hooks, an intermediate sclerite, and a basal sclerite. There may or may not be articulation between these regions, depending on the species. The basal sclerite consists of two dorsal and two ventral wings which are characteristic in shape for each species. Ventral to the intermediate sclerite there may be a hypopharyngeal sclerite.

NEODIPRION SERTIFER AND ITS PARASITES

N. sertifer was probably introduced from Europe and was first recorded in Canada in 1939 (Raizenne, 1957), in Lambton County near Sarnia and Windsor, Ont. It has since spread east of Hamilton and north to Owen Sound, Ont. (Griffiths, 1959). It is known to feed on *Pinus sylvestris* L., *Pinus resinosa* Ait., and *Pinus banksiana* Lamb. The species dealt with in this paper were listed as parasites of *N. sertifer* in Canada and Northern United States by Craighead (1950), Cushman (1940, 1943), Finlayson and Finlayson (1958a), Gahan (1938), Girth and McCoy (1946a, 1946b), Griffiths (1959), Peck (1951), Raizenne (1957), and Townes and Townes (1951).

Twenty-three species are described and illustrated in the present paper: 13 species, nine genera, four subfamilies of the family Ichneumonidae of the Ichneumonoidea, and six species, five genera, and four families of the Chalcidoidea in the Hymenoptera; and four species, four genera and two families in the Diptera.

Several species that have been reported rarely from *N. sertifer* are not included in this paper because specimens with the cocoons from which they emerged were not available. In the Hymenoptera, the braconid *Aspilota* sp. (hyperparasite), and the chalcidoid *Tetrastichus* sp. were reported by Griffiths (1959); and Girth and McCoy (1946a) reported *Agrothereutes lophyri* (Nort.) and *Euceros neodiprioni* Wly. from Kingston, N.J., U.S.A., but neither of these species has been recorded from *N. sertifer* in Canada. In the Diptera, Griffiths (1959) reported the phorid *Megaselia* sp., and Raizenne (1957) the tachinids *Neophocera* sp. and *Spathimeigenia* sp. The muscid *Muscina stabulans* (Fall.) was reared from *N. sertifer* by Griffiths (1959). It has not been included in this paper because it is a scavenger on many hosts and its presence on *N. sertifer* may have been accidental.

It was impossible to identify one species of Ichneumonidae, subfamily Cryptinae, that parasitized *N. sertifer* in the Sarnia, Ont. region as it was parasitized by the secondary parasite *Euceros frigidus* Cress. Unfortunately no other specimens with similar cephalic structures were encountered. It has been included in the key and described under the name Ichneumonid sp. A. The identity of this species will probably be discovered as parasites of other sawflies are investigated.

KEY TO PARASITES BASED ON COCOONS OR PUPARIA AND THEIR CONTENTS

1. Host cocoon not containing parasite puparium or cocoon 2
   Host cocoon containing parasite puparium or cocoon 7
2. Exit hole about 2.5 x 4 mm., directly at end of host cocoon, usually with cap attached; cephalic structure of last larval instar of the Bombyliid type (Fig. 19) ..... *Hemipenthes sinuosa* (Wied.) (p. 40)
   Exit hole 0.5 mm. to 1.1 mm. in diameter, not directly at end of host cocoon and usually on side; cephalic structure of last larval instar not as above 3
3. Cast skin of last larval instar covered with long hairs or setae 4
   Cast skin of last larval instar not covered with long hairs or setae 5
4. Skin sparsely covered with long setae (0.2 mm.); blades of mandibles curved; clypeus (heavily sclerotized, crescent-shaped, with one row of denticles) present (Figs. 16, 40) ..... *Eupelmella vesicularis* (Retz.) (p. 38)
   Skin densely covered with long hairs (0.4 mm.); blades of mandibles straight; clypeus absent (Figs. 17, 41) ..... *Monodontomerus dentipes* (Dalm.) (p. 39)
5. Cephalic structure of last larval instar showing only the mandibles 6
   Cephalic structure of last larval instar showing mandibles, epistoma, pleurostomae, superior and inferior mandibular processes, and reduced hypostomae (Figs. 18, 42) ..... *Tritneptis* spp. (p. 39)
6. Atrium of spiracle with about four divisions; secondary parasite (Fig. 43) ..... *Dibrachys cavus* (Wlkr.) (p. 40)
   Atrium of spiracle with about 10 to 14 divisions; usually primary parasite (Figs. 15, 39) ..... *Dahlbominus fuliginosus* (Nees) (p. 38)
7. Host cocoon containing puparium; exit hole on tip of cocoon 8
   Host cocoon containing cocoon; exit hole usually slightly to side of tip 10
8. Edge of exit hole sharply cut, usually with a hinged lid (Fig. 24) 9
   Edge of exit hole tapered and curled outward giving a pushed-out appearance (Figs. 23, 25) ..... *Spathimeigenia spinigera* Tns. (p. 45)
9. Length of mandibular hooks plus intermediate sclerite less than half total length of buccopharyngeal armature; distance from tip of hooks to postero-dorsal angle only slightly longer than distance from postero-dorsal angle to ventral projection of hooks (Fig. 21) ..... *Diplostichus hamatus* (A. & W.) (p. 42)

Length of mandibular hooks plus intermediate sclerite more than half total length of buccopharyngeal armature; distance from tip of hooks to postero-dorsal angle almost twice distance from postero-dorsal angle to ventral projection of hooks (Fig. 22) ..... *Neophorocera edwardsii* (Will.) (p. 42)

10. Host cocoon containing a partial parasite cocoon; cephalic structure of last larval instar as in Fig. 2 ..... *Delomerista diprionis* Cush. (p. 26)
Host cocoon containing a complete parasite cocoon; cephalic structure of last larval instar not as above 11

11. Parasite cocoon the same length and width as host cocoon, but flattened (Figs. 7, 31) ..... *Mastrus argeae* (Vier.) (p. 30)
Parasite cocoon approximately the same size and shape as host cocoon 12

12. Labial sclerite closed dorsally (Figs. 2, 26) ..... *Delomerista diprionis* Cush. (p. 26)
Labial sclerite open dorsally 13

13. Labial sclerite broken ventrally (Figs. 14, 38) ..... *Lamachus* sp. (p. 36)
Labial sclerite closed ventrally 14

14. Epistomal arch incomplete; labral sclerite visible; blades of mandibles with two rows of teeth 15
Epistomal arch complete; labral sclerite not visible; blades of mandibles without teeth 20

15. Mandibles each with a projection on the postero-dorsal edge of blade; antennae as wide as long or wider 16
Mandibles without a projection on the postero-dorsal edge of blade; antennae longer than wide 17

16. Projection on postero-dorsal edge of blade of each mandible small and tooth-like; silk press deeper than wide; hypostomal spur four times as long as its basal width (Figs. 8, 32) ..... *Endasys subclavatus* (Say), (p. 32)
Projection on postero-dorsal edge of blade of each mandible right-angled and conspicuous; silk press wider than deep; hypostomal spur about two and a half times as long as its basal width (Figs. 12, 36) ..... Ichneumonid sp. A. (p. 34)

17. Blade dorsally meets basal region of mandible at almost a right angle, and has two rows of smaller, even teeth 18
Blade dorsally meets basal region of mandible at angle greater than right angle, and has two rows of larger, uneven teeth 19

18. Antenna about one and a half times as long as its basal width; labial and maxillary palpi each with one sensorium; lacinial sclerite present; atrium of spiracle smaller, without reticulations (Figs. 11, 35) ..... *Agrothereutes* sp. possibly *rufopectus* Cush. (p. 33)
Antenna three to four times as long as its basal width; labial and maxillary palpi each with two sensoria; lacinial sclerite either absent or very hard to see; atrium of spiracle larger, with four to six reticulations (Figs. 7, 31) ..... *Mastrus argeae* (Vier.) (p. 30)

19. Hypostomal spur four to five times longer than wide; blade of each mandible swollen at bases of teeth; dorsal arms of labial sclerite relatively wider (Figs. 10, 34) ..... *Aptesis basizona* (Grav.) (p. 33)
Hypostomal spur about seven times as long as wide; blade of each mandible not or little swollen at bases of teeth; dorsal arms of labial sclerite more narrow (Figs. 9, 33) ..... *Aptesis indistincta* (Prov.) (p. 32)

20. Silk press barely visible; well-sclerotized prelabial sclerite extending almost to the dorsal arms of labial sclerite (Figs. 13, 37) ..... *Euceros frigidus* Cress. (p. 34)
Silk press well sclerotized and fully visible; prelabial sclerite absent 21

21. Hypostomal spur almost as wide at base as long; blade of mandible more narrow and needle-like; atrium of spiracle round 22
Hypostomal spur more than twice as long as its basal width; blade of mandible less narrow and less needle-like; atrium of spiracle tapered toward stalk or wider than deep 23

22. Height of epistomal arch above blades of mandibles about one-half its width at widest point; stipital sclerites each bent upward at approximately right angle at the labial sclerite (Figs. 6, 30) ..... *Exenterus walleyi* Cush. (p. 30)
Height of epistomal arch above blades of mandibles about two-thirds its width at widest point; stipital sclerites each curved gently upward at the labial sclerite (Figs. 4, 28) ..... *Exenterus abruptorius* (Thunb.) (p. 28)

23. Height of epistomal arch above blades of mandibles about one-half its width at widest point; atrium of spiracle tapering to stalk (Figs. 5, 29)..... *Exenterus amictorius* (Panz.) (p. 28)

Height of epistomal arch above blades of mandibles a little more than one-third its width at widest point; atrium of spiracle wider than deep (Figs. 3, 27)..... *Exenterus canadensis* Prov. (p. 26)

DESCRIPTIONS

HYMENOPTERA

Ichneumonoidea: Ichneumonidae

Pimplinae: Ephialtini

Delomerista diprionis Cush.

Figs. 2, 26

Delomerista diprionis Cush. was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Griffiths (1959); of *Neodiprion abietis* (Harr.) by Raizenne (1957) and Townes and Townes (1951); of *N. lecontei* (Fitch) by Benjamin (1955); of *N. nanulus* Schedl by Coppel (1954); of *N. tsugae* Midd. by Cushman (1939), Furniss and Dowden (1941), and Townes and Townes; of *Diprion frutetorum* (F.) by Raizenne; of *D. hercyniae* (Htg.) by Cushman (1939), Pierson (1941), and Townes and Townes; and of *D. similis* (Htg.) by Cushman (1939), Townes and Townes, and Raizenne.

Exit hole slightly to one side of end of host cocoon; fairly round, regular in shape; approximately 2.0 mm. in diameter. Parasite cocoon inside host cocoon varying from complete cocoon size and shape of host cocoon to small disc of spun material covering host remains. Small, black pellets of meconium characteristic of this species present in host cocoon, or parasite cocoon when complete. Cast skin of last larval instar loose, usually situated at end of cocoon opposite exit hole, absent in about 75 per cent of specimens examined, possibly indicating they were dragged from cocoon by emerging adult.

Cephalic structure of last larval instar (Fig. 2) with incomplete epistoma. Each superior mandibular process long, directed antero-medially; inferior mandibular processes each with two blunt struts; lacinial sclerite present. Short, heavy, hypostomal arms each extending mostly laterally in almost straight line. Each hypostomal spur extending ventrally from hypostoma, resting on medial end of greatly reduced stipital sclerite close to labial sclerite. Labial sclerite completely closed with greatly thickened ventral portion. Silk press lightly sclerotized; prelabial sclerite not apparent. Labral sclerite well arched, slightly enlarged dorsally. Mandibles each with slightly curved blade with two rows of very fine, inconspicuous teeth and a large, sharp, postero-medial tooth. Each antenna very small, as wide at base as long. Skin covered sparsely with long (0.13 mm.), conspicuous setae and densely with minute, cone-shaped papillae. Atrium of spiracle (Fig. 26) funnel-shaped, with reticulations, about as wide as long, opening directly into closing apparatus.

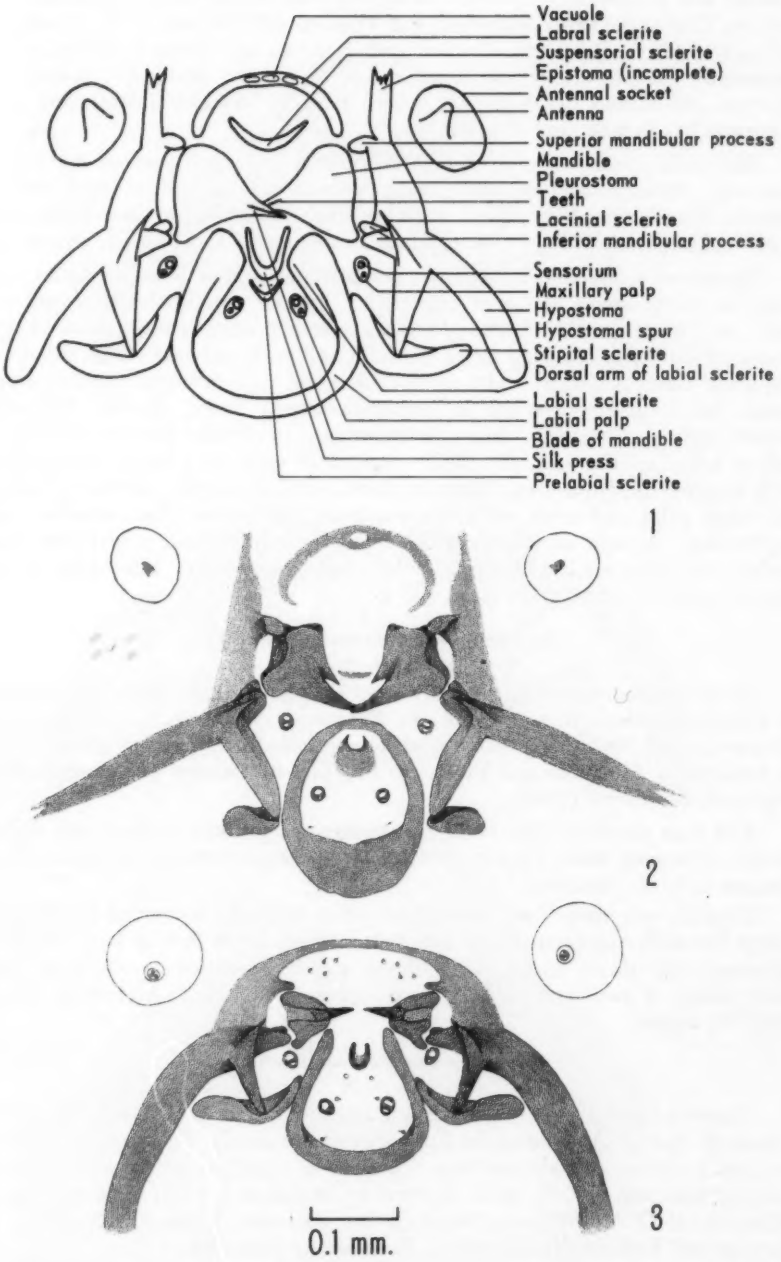
Tryphoninae: Exenterini

Exenterus canadensis Prov.

Figs. 3, 27

Four species of *Exenterus* are recorded from *N. sertifer* in Canada. To separate their larvae it is necessary to have perfect mounts of the cephalic structures, and even then there is sometimes some doubt.

Exenterus canadensis Prov. was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Griffiths (1959), and in the



Figs 1-3. Cephalic structures of final-instar hymenopterous larvae: 1, diagram of structures; 2, *Delomerista diprionis* Cush.; 3, *Exenterus canadensis* Prov.

northern United States by Cushman (1940, 1943), Girth and McCoy (1946a), and Townes and Townes (1951); of *N. abietis* by Raizenne (1957); of *N. banksianae* Roh. by Cushman (1940), Raizenne, and Townes and Townes; of *N. lecontei* by Benjamin (1955), Raizenne, Townes and Townes, and Walley (1933); of *N. nanulus* by Coppel (1954) and Raizenne; of *N. swainei* Midd. by Townes and Townes, and Walley; of *N. taedae linearis* Ross by Walkley (1958); and of *D. hercyniae* by Townes and Townes.

Exit hole almost on end of host cocoon; large, jagged; about 2.5 mm. in diameter. Parasite cocoon conforming to size and shape of host cocoon; whitish, thin, transparent, shiny, slightly fuzzy. Remains of last larval instar loose within parasite cocoon; usually near meconium at end opposite exit hole.

Epistomal arch (Fig. 3) narrow, complete; at widest point is almost three times its height above blades of mandibles. Inferior mandibular processes each with two blunt struts. Lacinial sclerite present, quite conspicuous. Hypostomata each heavy, curving latero-ventrally. Hypostomal spurs each about two and a half times as long as width at base, bisecting well developed stipital sclerite which bends gently upward at horseshoe-shaped labial sclerite. Silk press present, lightly sclerotized. Floor of pharynx with definite pattern of fine teeth behind labial sclerite and silk press. Mandibles each with long, pointed blade well marked off from base, without teeth. Labral sclerite absent. Maxillary and labial palpi each with one large, one small sensorium. Each antenna small, papilla-like. Atrium of spiracle (Fig. 27) with reticulations, wider than deep, leading into short stalk with thick-walled closing apparatus. Skin covered with minute spicules, a few short setae.

Exenterus abruptorius (Thunb.)

Figs. 4, 28

Extenterus abruptorius (Thunb.) is a European species which was liberated in Canada in attempts to control the European spruce sawfly. *D. hercyniae*, (Finlayson and Finlayson, 1958b) and was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a). Its biology was described and illustrated by Morris (1937).

Exit hole similar to that of *E. canadensis* in shape and position, but slightly smaller, averaging about 2.1 mm. in diameter. Parasite cocoon, position of larval remains as in *E. canadensis*.

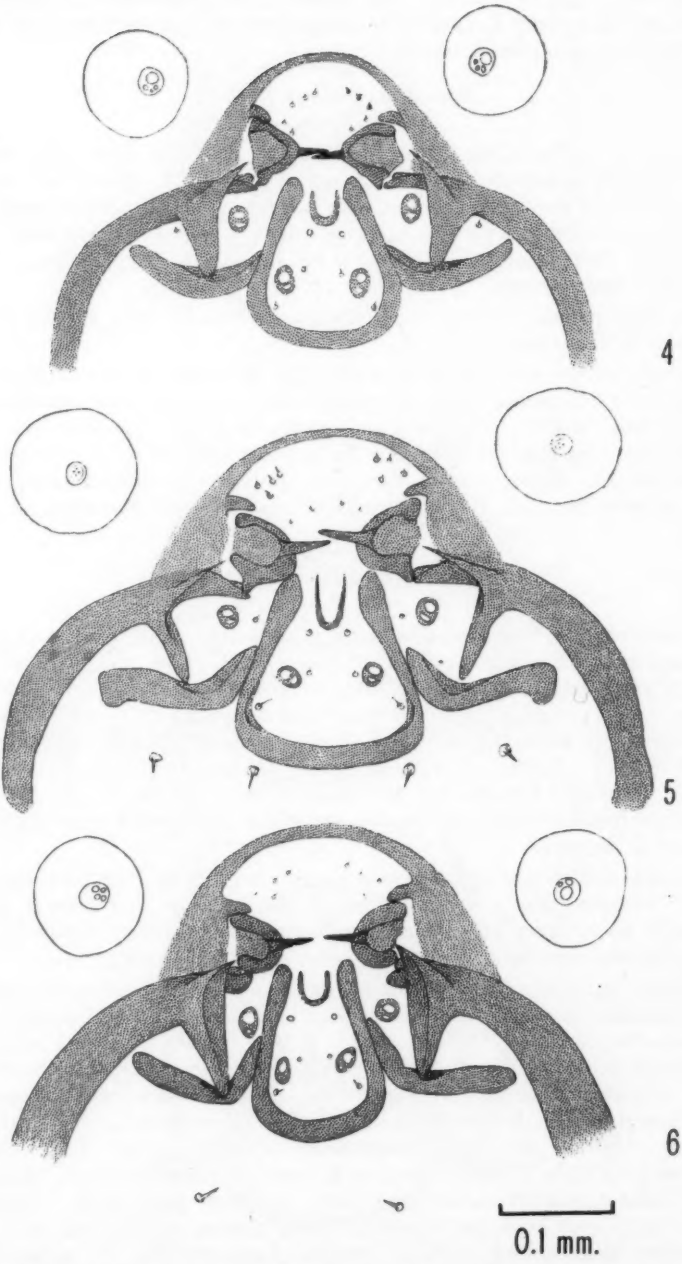
Cephalic structure of last larval instar (Fig. 4) similar to that of *E. canadensis* except for each hypostomal spur being almost as wide at base as long; height of epistomal arch above blades of mandibles about two-thirds its width at widest point; blade of each mandible narrower, more needle-like. Atrium of spiracle (Fig. 28) round.

Exenterus amictorius (Panz.)

Figs. 5, 29

Exenterus amictorius (Panz.) is a European species which was liberated in Canada in attempts to control the European spruce sawfly, *D. hercyniae*, (Finlayson and Finlayson, 1958b) and was recorded as a parasite of *N. sertifer* in Ontario by Raizenne (1957); of *N. lecontei* by Benjamin (1955); of *N. nanulus* by Raizenne; of *D. hercyniae* by Baird (1941), Raizenne, Reeks (1952, 1953), and Townes and Townes (1951); and of *D. similis* by Raizenne.

Exit hole and parasite cocoon similar in sizes and shapes to those of *E. abruptorius*. Cocoon sometimes with slight pinkish tinge.



Figs. 4-6. Cephalic structures of final-instar hymenopterous larvae: 4, *Exenterus abruptorius* (Thunb.); 5, *E. amictorius* (Panz.); 6, *E. walleyi* Cush.

Cephalic structure of last larval instar (Fig. 5) similar to that of *E. canadensis* except that height of epistomal arch above blades of mandibles about one-half its width at widest point, *E. canadensis* being about one-third. Atrium of spiracle (Fig. 29) tapering toward stalk.

Exenterus walleyi Cush.

Figs. 6, 30

Exenterus walleyi Cush. was reared at the Belleville laboratory from *N. sertifer* cocoons collected at Strathroy and Sarnia, Ont. These are the only known records of the species on this host, and are previously unpublished. The species was recorded as a parasite of *N. abietis* by Cushman (1943) and Townes and Townes (1951); and of *N. nanulus* by Coppel (1954), Cushman (1943), and Townes and Townes.

Exit hole, parasite cocoon, larval remains similar in sizes, shapes, positions to those of *E. canadensis*.

Cephalic structure of last larval instar (Fig. 6) similar to that of *E. canadensis* except each hypostoma is shorter, wider; each hypostomal spur almost as wide at base as long; height of epistomal arch above blades of mandibles one-half its width at widest part; each stipital sclerite bending upward at almost right angle at labial sclerite. Labial sclerite narrower ventrally than other three species. Atrium of most spiracles (Fig. 30) round, some with slight flattening on top.

Cryptinae: Hemitelini

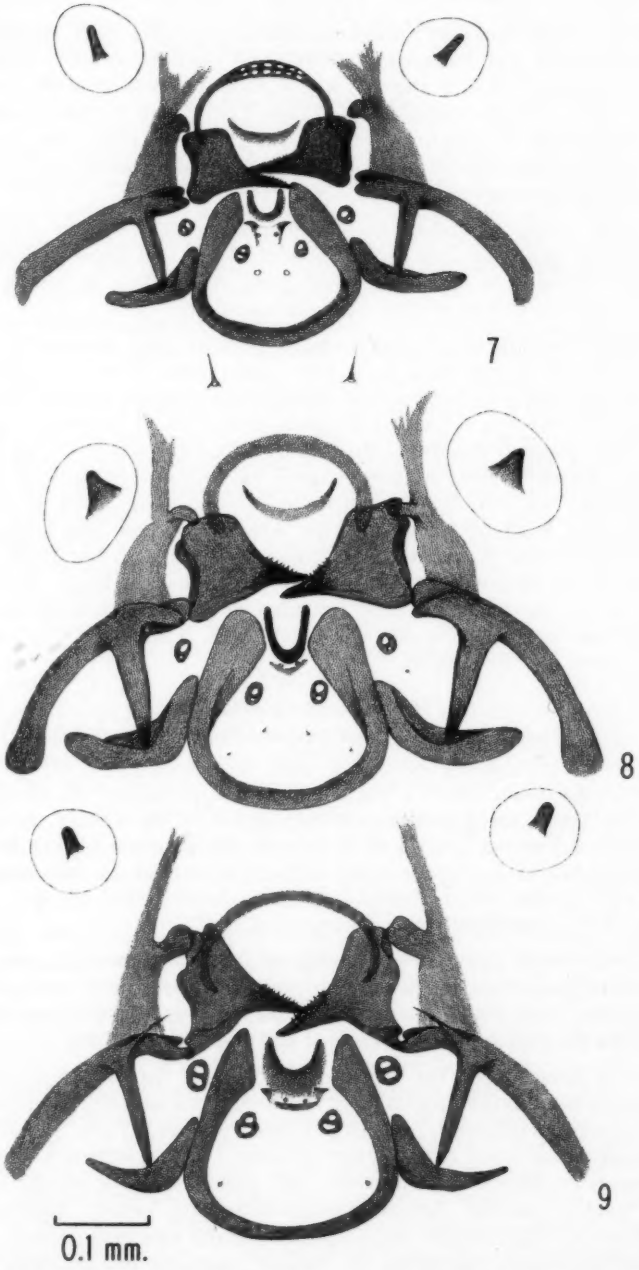
Mastrus argeae (Vier.)

Figs. 7, 31

Mastrus argeae (Vier.) was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Griffiths (1959), and in New Jersey by Girth and McCoy (1946a) (as *M. neodiprioni* (Vier.)); of *N. abietis* by Raizenne (1957); of *N. tsugae* by Townes and Townes (1951); of *D. hercyniae* by Townes and Townes; and of *Zadiprion grandis* (Roh.) by Furniss and Dowden (1941). Griffiths (1959) recorded *M. aciculatus* (Prov.) as a parasite of *N. sertifer* in Ontario but Mr. G. S. Walley and Dr. W. R. M. Mason, Entomology Research Institute, Ottawa, stated that this species is not distinguishable from *M. argeae*.

Exit hole well to side of tip of host cocoón, regular in shape, diameter about 1.5 mm. Parasite cocoon with same length and width as host cocoon but flattened, with thick, fuzzy edge; whitish to light buff in colour; transparent, thin, brittle. Parasite remains are free at end of cocoon opposite exit hole.

Cephalic structure of last larval instar (Fig. 7) with incomplete epistoma. Inferior mandibular processes each with two long, blunt struts. Lacinial sclerite, if present, very indistinct, difficult to see. Labial sclerite U-shaped with lateral arms slightly thickened dorsally. Silk press present between upper arms of labial sclerite. Prelabial sclerite appearing as two small sclerotized areas beneath silk press. Labral sclerite dorsally thickened with small vacuoles, arched down over mandibles. Weakly sclerotized suspensorial sclerite present. Each mandible large, with long blade with two rows small, even, inconspicuous teeth; blades each meeting basal region of mandible dorsally at almost right angle. Labial and maxillary palpi each with two sensoria. Each antenna slender, narrow at base, three to four times as long as wide. Atrium of spiracle (Fig. 31) goblet-shaped, with reticulations, opening into annulated stalk with closing apparatus. Skin with a few setae, many small, papilla-like projections.



Figs. 7-9. Cephalic structures of final-instar hymenopterous larvae: 7, *Mastrus argeae* (Vier.); 8, *Endasys subclavatus* (Say); 9, *Aptesis indistincta* (Prov.).

Endasys subclavatus (Say)

Figs. 8, 32

Endasys subclavatus (Say) was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Griffiths (1959), and in New Jersey by Craighead (1950) and Girth and McCoy (1946a); of *N. lecontei* by Benjamin (1955); of *N. nanulus* by Coppel (1954); of *N. taedae linearis* by Walkley (1958); of *N. tsugae* by Furniss and Dowden (1941) and Townes and Townes (1951); of *D. hercyniae* by Reeks (1938) and Townes and Townes; and of Z. *grandis* by Townes and Townes.

Exit hole almost on end of host cocoon, irregularly oval in outline, about 1.9 mm. by 1.6 mm. Parasite cocoon similar in size and shape to host cocoon; thin, shiny, mica-like in appearance; dark grey to blackish in colour. Parasite remains are free at end of cocoon opposite exit hole.

Cephalic structure of last larval instar (Fig. 8) with incomplete epistoma. Inferior mandibular processes each with two blunt struts. Lacinial sclerite absent. Hypostomata each extending laterally and ventrally in well rounded arc. Labial ring U-shaped with widened dorsal arms twisted in relation to ventral portion. Silk press U-shaped, conspicuous. Prelabial sclerite narrow, lightly sclerotized. Labral sclerite anterior to and extending slightly over mandibles. Suspensorial sclerite showing as concave sclerotized area below labral sclerite. Mandibles each with blade having two rows teeth and one large, rounded postero-medial tooth. Labial and maxillary palpi each with one large, one small sensorium. Each antenna papilla-shaped, as wide at base as long. Spiracle (Fig. 32) with large, heavy atrium with reticulations opening directly into closing apparatus; stalk approximately same length as width of atrium. Skin with minute papillae, a very few short setae.

Cryptinae: Aptesini

Aptesis indistincta (Prov.)

Figs. 9, 33

Aptesis indistincta (Prov.) was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Griffiths (1959); of *N. abietis* by Townes and Townes (1951); of *N. lecontei* by Benjamin (1955) and Townes and Townes; and of *D. hercyniae* by Reeks (1938) and Townes and Townes. Townes and Townes also recorded it from *Nematus ribesii* (Scop.), *Pikonema alaskensis* (Roh.), and *Pristiphora erichsonii* (Htg.).

Exit hole evenly rounded, to one side of tip of host cocoon, about 1.6 mm. in diameter. Parasite cocoon whitish to grey in colour, fuzzy on outer surface, thin, mica-like, conforming to shape of host cocoon. Parasite remains are in black meconium inside parasite cocoon at end opposite exit hole.

Cephalic structure of last larval instar (Fig. 9) with incomplete epistoma. Each superior mandibular process long, heavy; inferior mandibular processes each with two long, curved struts. Lacinial sclerite present. Each hypostomal spur long, slender, about seven times as long as wide. Labial sclerite U-shaped, with dorsal arms wider than ventral portion. Silk press U-shaped, heavily sclerotized. Prelabial sclerite present. Mandibles each with long, heavily pigmented blade with two rows long, irregular teeth. Labral sclerite rounded, narrow, extending about half way down mandibles; no vacuoles apparent in specimens examined. Long suspensorial sclerite present and appearing under mandibles. Maxillary and labial palpi each with two large sensoria. Each antenna almost same width

at tip as at base, about twice as long as wide. Atrium of spiracle (Fig. 33) slightly tapered, with reticulations, about as deep as length of stalk, opening directly into closing apparatus. A few longer spines present on skin amongst covering of cone-shaped papillae.

Aptesis basizona (Grav.)

Figs. 10, 34

Aptesis basizona (Grav.) is a European parasite which was liberated in Canada in attempts to control the European spruce sawfly, *D. hercyniae*, (Finlayson and Finlayson, 1958b, 1958c) and was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson, (1958a), and of *D. hercyniae* by Reeks (1953) and Townes and Townes (1951). The last larval instar was described and illustrated by Morris, Cameron, and Jepson (1937).

Exit hole evenly rounded, almost on tip of host cocoon, approximately 1.9 mm. in diameter. Parasite cocoon similar in size and shape to host cocoon; thick, layered, shiny, slightly fuzzy; grey-brown in colour. Parasite remains are either loose or in meconium at end of cocoon opposite exit hole.

Cephalic structure of last larval instar (Fig. 10) similar to *A. indistincta* except that dorsal arms of labial sclerite wider, prelabial sclerite more pronounced, hypostomal spurs four to five times longer than wide, labral sclerite dorsally wider with vacuoles, blade of each mandible swollen at bases of teeth. Atrium of spiracle (Fig. 34) cup-shaped with reticulations, stalk usually with two or three annulations above closing apparatus.

Cryptinae: Cryptini

Agrothereutes sp. possibly *rufopectus* Cush.

Figs. 11, 35

Agrothereutes sp. possibly *rufopectus* Cush. was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a). As only one specimen was available for examination, the following description is given with some reservation.

Exit hole to one side of tip; round, slightly irregular; about 1.6 mm. in diameter. Parasite cocoon similar in size, shape to host cocoon; white, loosely-woven, transparent, thin. Larval remains loose at end of cocoon opposite exit hole.

Cephalic structure of last larval instar (Fig. 11) with incomplete epistoma. Each superior mandibular process exceptionally long with indentation directly below base. Each inferior mandibular process long, curved; impossible to distinguish whether consisting of one or more struts from one specimen examined. Lacinial sclerites present. Hypostomal arms each long, arching latero-ventrally, curving slightly inward ventrally. Hypostomal spurs each long, slender. Labial sclerite widely U-shaped with lateral arms broadened dorsally. Silk press not heavily sclerotized; prelabial sclerite not apparent. Labral sclerite highly arched, containing several small vacuoles dorsally. Each blade dorsally meeting basal region of mandible at almost right angle, with two rows even teeth. Lightly sclerotized suspensorial sclerite possibly present. Maxillary and labial palpi each with one sensorium. Each antenna large, conspicuous, about one and a half times as long as width at base. Atrium of spiracle (Fig. 35) globular in shape, without reticulations, less than half as wide as stalk is long. A few short setae scattered over body in addition to densely packed conical spinules.

Ichneumonid sp. A.

Figs. 12, 36

This species parasitized one cocoon of *N. sertifer* in the Sarnia, Ont. region. It in turn was parasitized by the secondary parasite *Euceros frigidus* Cress. (see under *E. frigidus*). As an adult was not available for identification, it is impossible to name the species. However, the form of the cephalic structure of the last larval instar indicates that it belongs in the subfamily Cryptinae, possibily tribe Cryptini (Beirne, 1941). A number of other specimens of this same species were found parasitized by *E. frigidus*, the host in these cases being *N. nanulus*.

Parasite cocoon conforming in size, shape to host cocoon; greyish-black in colour; finely woven, thick, layered, lacking fuzz.

Cephalic structure of last larval instar (Fig. 12) heavy-looking, well sclerotized. Epistoma incomplete meeting each pleurostoma at apparently two-pronged superior mandibular process. Inferior mandibular processes each with two blunt struts. Lacinial sclerites lacking. Hypostomal arms each short, heavy, extending in shallow arc latero-ventrally with slight medial projection at ventral end. Hypostomal spurs each about 2½ times as long as basal width, extending ventrally to boat-shaped stipital sclerite. Labial sclerite widely U-shaped with lateral arms considerably wider than ventral portion. Silk press heavily sclerotized, as wide as or wider than deep. Prelabial sclerite evident beneath silk press. Each mandible with short blade with two rows of teeth and a conspicuous right-angled projection on postero-dorsal edge. Labral sclerite well-arched, dorsally containing a few vacuoles. Suspensorial sclerite evident between dorsal tips of mandibles. Labial and maxillary palpi each with one large, one small sensorium. Each antenna about 1½ times as wide at base as long. Spiracle (Fig. 36) large with atrium about as wide as length of stalk. Skin densely covered with dome-shaped protuberances, a few short setae.

Mesoleiinae: Euceratini

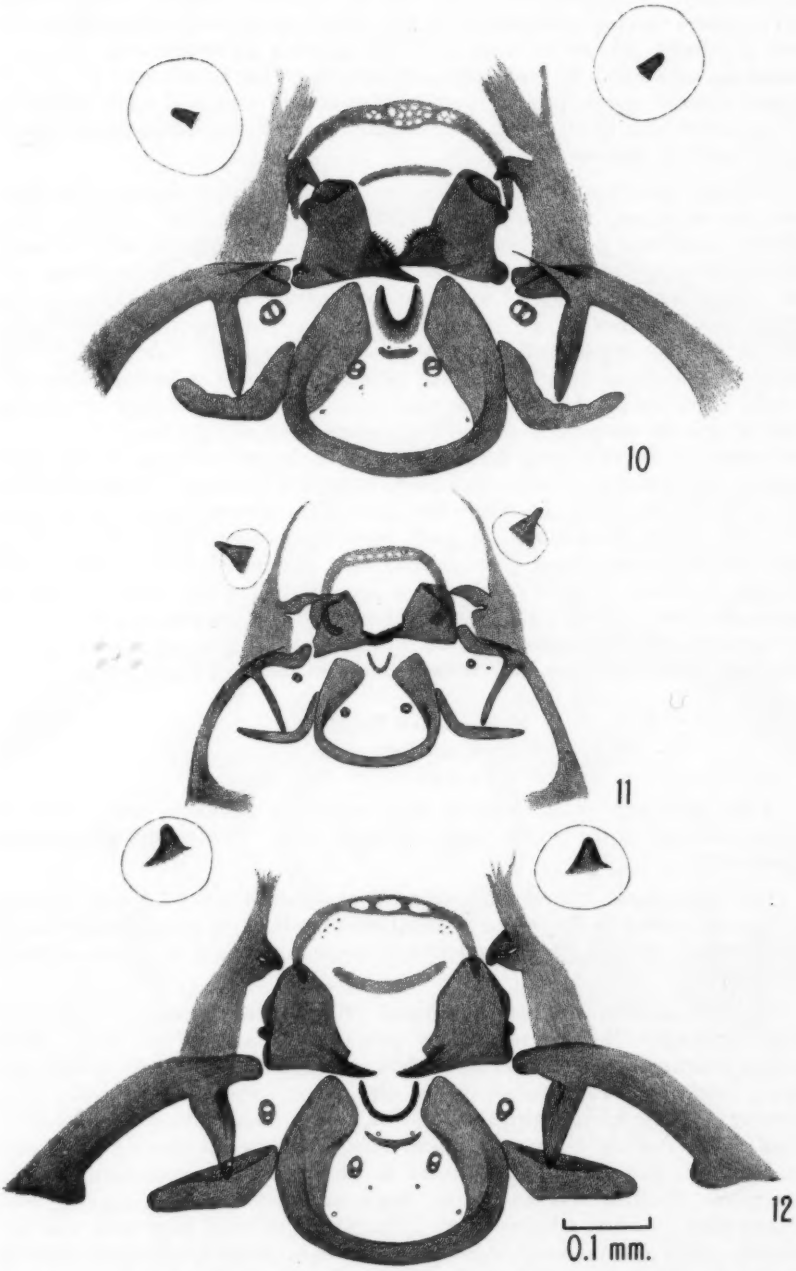
***Euceros frigidus* Cress.**

Figs. 13, 37

Euceros frigidus Cress. was recorded from *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Griffiths (1959); from *N. abietis* by Townes and Townes (1951); from *N. lecontei* by Raizenne (1957); from *N. nanulus* by Coppel (1954), Raizenne, and Townes and Townes; and from *N. pratti banksianae* by Raizenne.

Only one specimen of this species from *N. sertifer* was available for examination. To confirm a number of features thought to be present in the cephalic structure of the last larval instar, cocoons of *N. banksianae* and *N. nanulus* from which *E. frigidus* had emerged were dissected and microscopic slides of the larval remains were made. These showed a diversity of types, two occurring most frequently. Mr. G. S. Walley, Entomology Research Institute, Ottawa, suggested that *E. frigidus* might be a secondary parasite as it possessed a planidium type larva and was unusual in a number of other respects. He provided a large number of specimens from the Canadian National Collection for further examination. It was soon found that *E. frigidus* is indeed a secondary parasite, and of the specimens examined, the primary parasites were 66% Mesoleiinae, 17% Tryphoninae, 13% Cryptinae, and 4% Anomalinae (Beirne, 1941).

The similarity of the cephalic structure to that of *Exenterus* would indicate that the systematic position of this genus might be in the Tryphoninae rather than the Mesoleiinae where it is now placed.



Figs. 10-12. Cephalic structures of final-instar hymenopterous larvae: 10, *Aptesis basizona* (Grav.); 11, *Agrothereutes* sp. possibly *rufopectus* Cush.; 12, Ichneumonid sp. A.

Exit hole almost on tip of cocoon; round, sometimes jagged, sometimes smooth in outline; approximately 2.5 mm. by 2.0 mm. Parasite cocoon within sawfly cocoon varying in thickness, texture, colour, depending on species that has acted as primary parasite of sawfly. Within primary parasite cocoon, at end of cocoon opposite exit hole, meconium and remains of last larval instar of primary parasite situated against primary parasite cocoon and separated from meconium and remains of last larval instar of *E. frigidus* by small but recognizable disc of cocoon spun by *Euceros*.

Cephalic structure of last larval instar (Fig. 13) large, lightly sclerotized. Epistoma complete, very lightly sclerotized, often broken dorsally. Each superior mandibular process peculiar in apparently possessing two arms of sclerotized tissue extending to either side of mandible. Each inferior mandibular process with two blunt struts. Lacinial sclerite present but weak and sometimes difficult to distinguish. Each hypostoma long, extending in straight line latero-ventrally. Each hypostomal spur long, slender, straight. Labial sclerite U-shaped with widened dorsal arms often twisting to appear as having lateral projections from them. Silk press present, not sclerotized, scarcely discernible. Prelabial sclerite prominent, shallowly U-shaped stretching almost to arms of labial sclerite. Rows of very fine teeth arranged in pattern similar to fish scales apparent between arms of labial ring dorsal to prelabial sclerite. Mandibles large, each with slender, sharp, heavily sclerotized blades without teeth. Labial palpi each with one large, two or more small sensoria; maxillary palpi each with one large, one small sensorium. Each antenna long, slender, about six times as long as wide. Spiracle (Fig. 37) delicate in appearance; atrium round, sometimes slightly flattened on top, free of reticulations; stalk long, many annulated, without apparent closing apparatus. Cast skin of last larval instar closely covered with fine, cone-shaped papillae, interspersed with occasional short setae.

Mesoleiinae: Mesoleiini

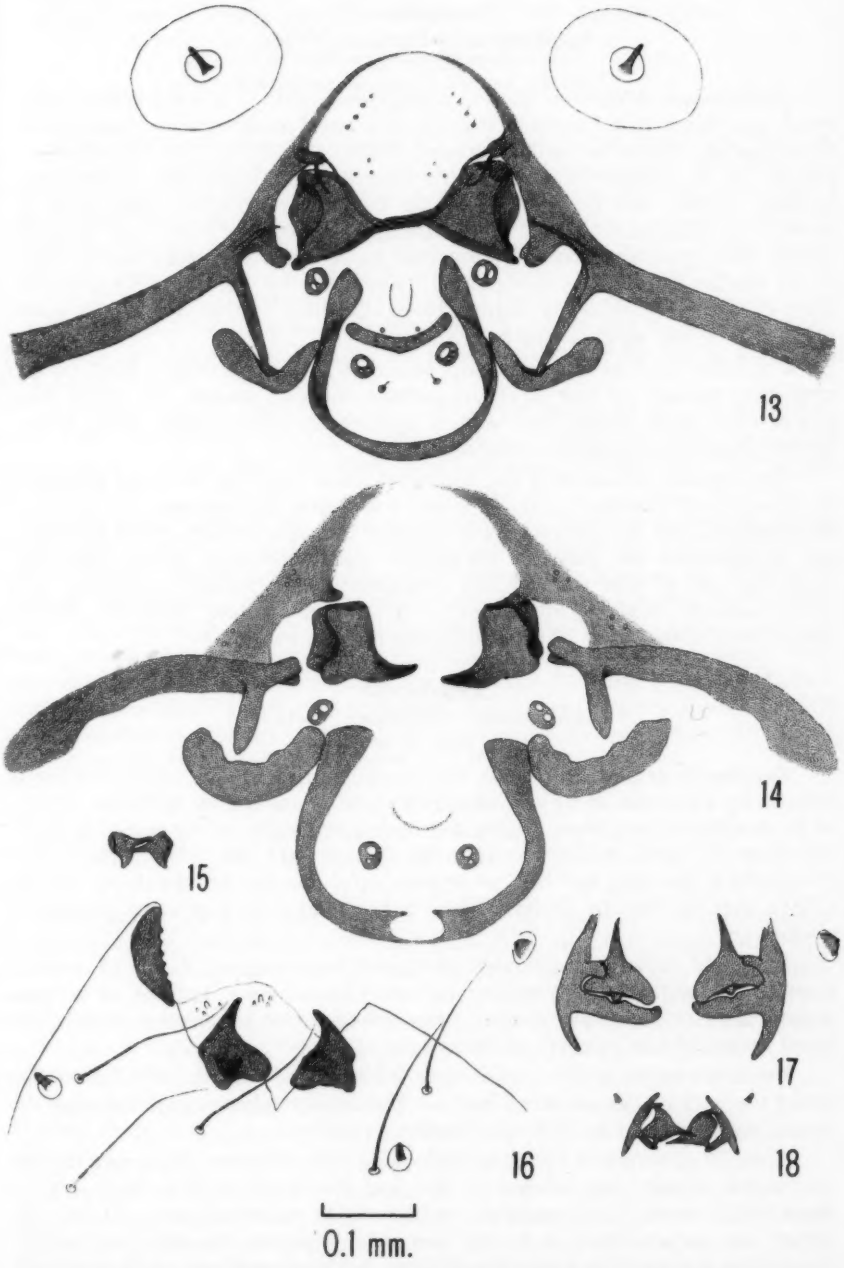
***Lamachus* sp.**

Figs. 14, 38

Two specimens of this species were reared in Belleville, Ont., from *N. sertifer* collected in the Sarnia, Ont., region in 1946. This record is previously unpublished.

Exit hole jagged, irregular in outline, approximately 2.5 x 2.1 mm. Parasite cocoon conforming to size, shape of host cocoon; whitish in colour; thin, layered, slightly fuzzy. Larval remains attached to meconium at end of cocoon opposite exit hole.

Cephalic structure of last larval instar (Fig. 14) with almost complete but diffuse epistoma. Inferior mandibular processes each with two blunt struts. Lacinial sclerite not evident. Hypostomal arms each long, arched laterally and slightly ventrally. Hypostomal spurs each short, projecting ventrally from hypostoma to meet large stipital sclerite at top of dorsal arm of labial sclerite. Labial sclerite widely U-shaped, broken ventrally, terminal part of each dorsal arm swollen. Silk press deeply placed in labial ring, not sclerotized, scarcely discernible. Prelabial sclerite absent. Each mandible with long curving blade without teeth. Labral sclerite absent. Maxillary and labial palpi each with two sensoria. Each antenna small, inconspicuous. Skin covered with small scale-like protuberances. Atrium of spiracle (Fig. 38) very small, round, about same width as stalk; closing apparatus apparently lacking.



Figs. 13-18. Cephalic structures of final-instar hymenopterous larvae: 13, *Euceros frigidus* Cress.; 14, *Lamachus* sp.; 15, *Dahlbominus fuliginosus* (Nees); 16, *Eupelmella vesicularis* (Retz.); 17, *Monodontomerus dentipes* (Dalm.); 18, *Tritneptis diprionis* Gah.

Chalcidoidea: Eulophidae
Eulophinae
***Dahlbominus fuliginosus* (Nees)**
Figs. 15, 39

Dahlbominus fuliginosus (Nees) (*fuscipennis* (Zett.)) is a European species which was liberated in Canada in attempts to control the European spruce sawfly, *D. hercyniae*, (Finlayson and Finlayson, 1958b, 1958c). It was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Griffiths (1959), and in New Jersey by Girth and McCoy (1946b); of *N. lecontei* by Benjamin (1955); of *N. nanulus* by Coppel (1954) and Raizenne (1957); of *N. pinetum* (Nort.) by Raizenne; of *N. pratti banksianae* by Raizenne; of *N. swainei* by Burks (1958); of *D. frutetorum* by Baird (1939) and Peck (1951); of *D. hercyniae* by Baird (1939), Dowden (1939), Peck, and Reeks (1952, 1953); and of *D. similis* by Peck.

Exit hole round, to one side of tip, about 0.6 mm. in diameter. Host cocoon containing remains of host larva; no parasite cocoons; several cast pupal skins; several very small, thread-like, whitish casts of last larval instar; small, beige-brown globules or elongated excretions.

The cephalic structure of the last larval instar was described and illustrated by Morris and Cameron (1935). They stated that the epistoma is broad and flattened, and that the pleurostomata, superior and inferior mandibular processes, and hypostomata are present. In mounts made from cast larval skins only mandibles and spiracles were visible. Mandibles (Fig. 15) each triangular, with strong, straight blades without teeth. Atrium of spiracle (Fig. 39) funnel-shaped, with about 10 to 14 definite chambers; stalk narrow.

Eupelmidae
***Eupelmella vesicularis* (Retz.)**
Figs. 16, 40

Eupelmella vesicularis (Retz.) was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a); of *N. abietis* by Raizenne (1957); of *N. banksianae* by Gahan (1938) and Peck (1951); and it was reared at Belleville from *D. similis* collected in Oakville, Ont. in 1933 and 1934. This is often a secondary parasite, and one or several may develop on the host. Morris (1938) showed that the preferred host is *D. fuliginosus*, a primary parasite of sawflies.

Exit hole slightly to one side of tip of host cocoon, about 0.8 mm. in diameter. Host cocoon containing remains of host larva, remains of primary parasite larva or pupa, one or more straw-coloured cast pupal skins, casts of last larval instar, blackish pellets of meconium.

Immature stages of this species were described by Morris (1938) who illustrated the head of the last larval instar. The remains after emergence were discussed and illustrated by Hill and Pinckney (1940).

Cephalic structure of last larval instar (Fig. 16) with crescent-shaped, heavily sclerotized clypeus (the labrum of Hill and Pinckney) with a single row of dome-shaped teeth. Four pairs of papillae visible below clypeus. Morris described the mature larva as having complete epistoma, superior and inferior mandibular processes, long hypostomal arms, but these were not visible in mounts of cast skins. Mandibles with curved blades without teeth. Each antenna about twice as long as wide. Skin sparsely covered with long (about 0.23 mm.) setae.

Atrium of spiracle (Fig. 40) large, funnel-shaped, with numerous chambers, opening into small closing apparatus followed by long annulated stalk.

Torymidae: Monodontomerinae
***Monodontomerus dentipes* (Dalm.)**
Figs. 17, 41

Monodontomerus dentipes (Dalm.) is a European species which was liberated in Canada in attempts to control the European spruce sawfly, *D. hercyniae*, (Finlayson and Finlayson, 1958b, 1958c). Nine specimens were reared in Belleville by Dr. W. F. Baldwin from one cocoon of *N. sertifer* collected at Bright's Grove, near Sarnia, Ont., in 1946. This is the first known record of this species on *N. sertifer* in Canada. It was recorded as a parasite of *N. pinetum* by Cushman (1943); of *D. frutetorum* by Raizenne (1957); of *D. hercyniae* by Peck (1951); and of *D. similis* by Baird (1939), Peck, Raizenne, and Thompson (1944). Its biology was discussed and the last larval instar illustrated by Morris, Cameron, and Jepson (1937).

Exit hole jagged, slightly to one side of tip, about 1.1 mm. in diameter. Host cocoon containing remains of host larva, no parasite cocoons, several cast pupal skins showing long ovipositor sheath of adult, several cast skins of last instar larvae.

Cephalic structure of last larval instar (Fig. 17) with reduced parts. Mandibles large, each with a rounded protuberance on articulating side; blade sharp, free of teeth. Epistoma incomplete; each pleurostoma terminating dorsally in superior mandibular process; each inferior mandibular process greatly elongated with mandile resting along its length; hypostomata present but greatly reduced. None of other structures present in specimens examined. Each antenna large, cup-shaped, situated in small antennal socket. Spiracle (Fig. 41) large, funnel-shaped; atrium thick-walled with numerous reticulations, opening into short stalk with small closing apparatus. Skin densely covered with long (about 0.43 mm.) hairs emerging from papilla-like bases.

Pteromalidae
Pteromalinae: Pteromalini
***Tritneptis* spp.**
Figs. 18, 42

Two species of *Tritneptis* were recorded as parasites of *N. sertifer*, namely, *T. diprionis* Gah. by Gahan (1938) and Peck (1951), and *T. klugii* (Ratz.) by Griffiths (1959). *T. diprionis* was recorded as a parasite of *N. pratti banksianae*, *N. lecontei*, *N. pinetum*, *D. hercyniae*, and *D. similis* by Raizenne (1957). *T. klugii* was recorded from *N. banksianae* by Gahan, and Peck; from *N. tsugae* by Furniss and Dowden (1941), Gahan, and Peck; from *D. hercyniae* by Peck; and from *P. erichsonii* by Gahan and Peck.

Reliable characteristics to separate the two species were not found. However, Dr. O. Peck, Entomology Research Institute, Ottawa, stated that the species encountered on *N. sertifer* would almost always be *T. diprionis*.

Exit hole round, smooth in outline; on side of cocoon, usually toward end; about 0.5 mm. in diameter. Host cocoon containing remains of sawfly larva; many straw-coloured cast pupal skins; possibly some dead larvae, pupae, adults; small, thread-like, whitish cast skins of last larval instar; meconium sometimes in long annulated strips. In specimens examined, meconium of *T. diprionis* blackish, of *T. klugii* black with some lighter coloured bits.

Cephalic structure of last larval instar of *T. diprionis* (Fig. 18) similar in form to *M. dentipes*, but much smaller. Mandibles each with sharp, toothless blade; a protuberance on articulating surface. Epistoma incomplete; superior and inferior mandibular processes long, well formed, with latter longer than former. Hypostomae greatly reduced in size extending ventrally in almost straight lines from either pleurostoma. No other cephalic structures present. Antennae discernible, each being almost twice as long as width at base. Atrium of spiracle (Fig. 42) funnel-shaped with about six chambers before entering narrow stalk with small closing apparatus. Skin without hairs or protuberances of any kind.

***Dibrachys cavus* (Wlkr.)**

Fig. 43

This species is usually a hyperparasite and has been recorded from many lepidopterous, hymenopterous, dipterous, and coleopterous hosts. It was recorded from *N. sertifer* in Ontario by Raizenne (1957); from *N. abietis* by Peck (1951); from *N. lecontei* by Benjamin (1955); from *D. similis* by Peck, and Thompson (1944); and from *D. hercyniae* by Peck. Morris, Cameron, and Jepson (1937) described the mature larva.

Exit hole varying from 0.6 mm. to 0.8 mm. in diameter, on side of cocoon, often toward end. Host cocoon containing remains of host larva, remains of primary parasite larva or pupa, numerous minute cast skins of last larval instar, cast pupal skins.

Cephalic structure of last larval instar showing only mandibles, spiracles. Mandibles similar to those of *D. fuliginosus*, and not a reliable separating character. Atrium of spiracle (Fig. 43) characteristic in having about four definite chambers rather than 10 to 14 as in *D. fuliginosus*.

DIPTERA

Bombyliidae

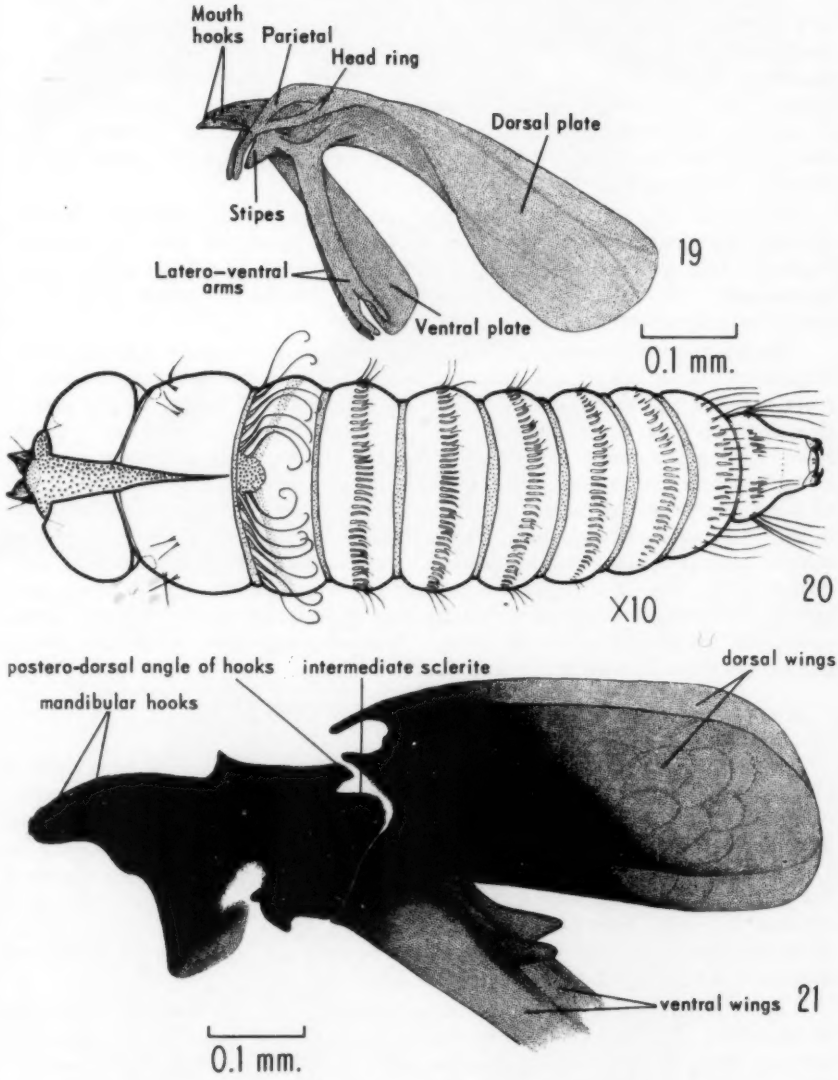
***Hemipenthes sinuosa* (Wied.)**

Figs. 19, 20

Hemipenthes sinuosa (Wied.) was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Griffiths (1959), and of *Neodiprion* sp. by Brooks (1952).

Exit hole large (about 2.5 mm. x 3.4 mm.), directly on end of cocoon with cap attached. Pupal skin if left attached to edge of exit hole as in Fig. 20. Remains of last larval instar loose at end of cocoon opposite exit hole.

Head armature of last larval instar (Fig. 19) lightly sclerotized, about 0.51 mm. long and 0.26 mm. wide at widest point. Mouth hooks lightly sclerotized, curving gently antero-ventrally, sparsely covered on apical two thirds with irregularly spaced, backward facing spines. Posterior and ventral parts of parietals joining to form head ring, which is broken ventrally. Stipes visible laterally and ventrally to hooks, labrum not visible from lateral view. Dorsal plate large, flat, drooping ventrally on either side, joining anteriorly with parietals and latero-ventrally with two posteriorly bifurcate latero-ventral arms. Ventral plate shorter than dorsal plate, rounded apically, extending caudad between the two latero-ventral arms. Two pairs spiracles present, each consisting of cylindrical atrium or felt chamber about 0.071 mm. long, terminating in bell-shaped structure about 0.13 mm. wide containing about nine respiratory papillae; stalk about 0.48 mm. long.



Figs. 19-21. 19, 21, Lateral views of buccopharyngeal apparatus of final-instar dipterous larvae: 19, *Hemipenthes sinuosa* (Wied.); 21, *Diplostichus hamatus* (A. and W.). 20, dorsal view of cast pupal skin of *H. sinuosa*.

Tachinidae

Diplostichus hamatus (A. and W.)

Figs. 21, 24

Diplostichus hamatus (A. and W.) was recorded as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a) and Raizenne (1957); of *N. banksianae*, *N. lecontei*, and *N. nanulus* by Baldwin and Coppel (1949) and Raizenne; of *D. hercyniae* by Reeks (1938) and Raizenne; of *D. similis* by Aldrich and Webber (1924) and Thompson (1944); and of *N. abbotii* (Leach), *N. abietis*, *N. pinetum*, *N. swainei*, and *D. frutetorum* by Raizenne. The emergence hole and biology of this species were described and illustrated by Baldwin and Coppel (1947, 1949).

Exit hole (Fig. 24) round, sharply cut; on tip of host cocoon; with flap attached by small, connecting piece of cocoon; about 2.3 mm. in diameter. Puparium free within host cocoon; dark reddish brown in colour; brittle, semi-transparent, with thin, white transparent lining. Hooks of mature larva at exit end, attached to inner surface of puparium.

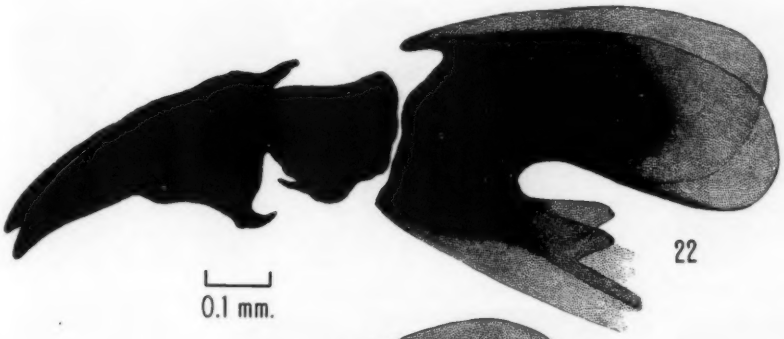
Buccopharyngeal armature of last-instar larva (Fig. 21) about 0.87 mm. long. Mandibles heavily sclerotized, broad, curving gently antero-ventrally. Distance from anterior tip of mandibular hooks to postero-dorsal angle slightly greater than distance from postero-dorsal angle to ventral projection of hooks. Hooks fused with intermediate region with slight constriction at point of junction. Length of mandibular hooks plus intermediate sclerite less than half total length of buccopharyngeal armature. Intermediate region heavily sclerotized, showing distinct articulation with basal region. Heavily sclerotized hypopharyngeal sclerite ventral to intermediate sclerite. Basal sclerite dividing into two wide dorsal wings, two shorter, narrower, ventral wings. Each dorsal wing more heavily sclerotized anteriorly, with indication of posterior veining; anterior dorsal projection on margin of dorsal wings. Ventral wings each with acute dorsal projection, more heavily sclerotized dorsally.

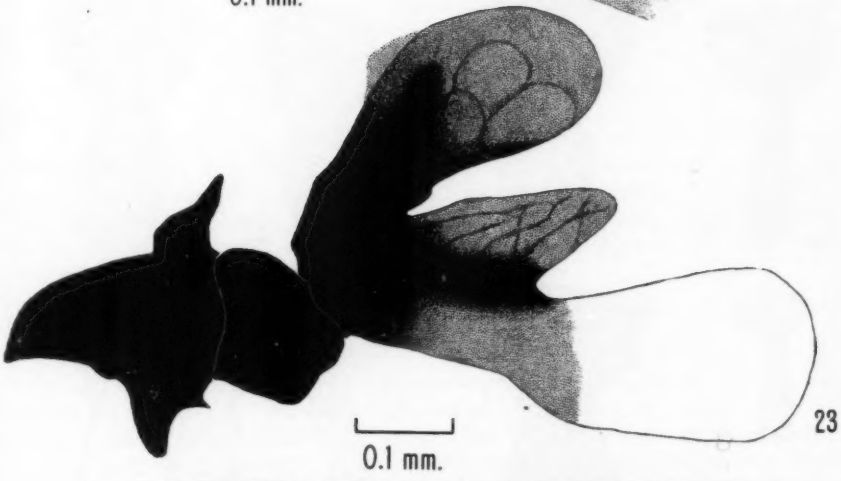
Neophorocera edwardsii (Will.)

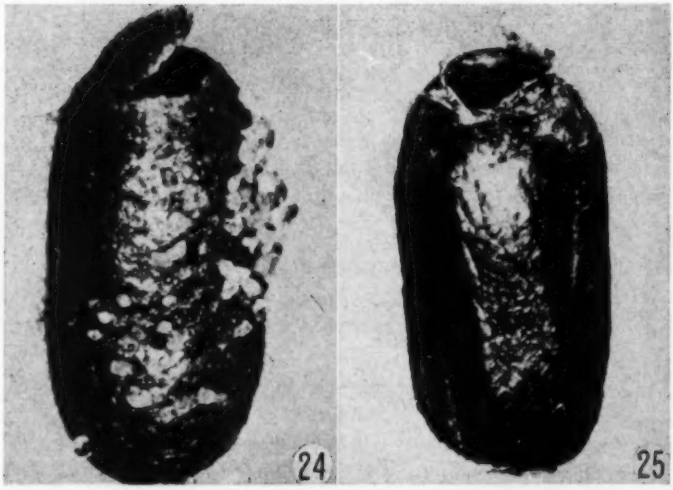
Fig. 22

Neophorocera edwardsii (Will.) was recorded as a parasite of *N. sertifer* in Ontario by Raizenne (1957) as *N. claripennis* (Macq.); of *N. americanus americanus* (Leach) by Hetrick (1941); of *N. lecontei* by Benjamin (1955) and Thompson (1944); and of *N. virginiana* Roh. and *D. similis* by Thompson. No cocoons from which it emerged were available for study, so that it is not known if the puparium is formed within the host cocoon, as in the case of *D. hamatus*, or whether the larva leaves the cocoon to pupate. Some puparia of this species were obtained from other hosts and the buccopharyngeal armature described and illustrated was from *Malacosoma disstria* Hbn.

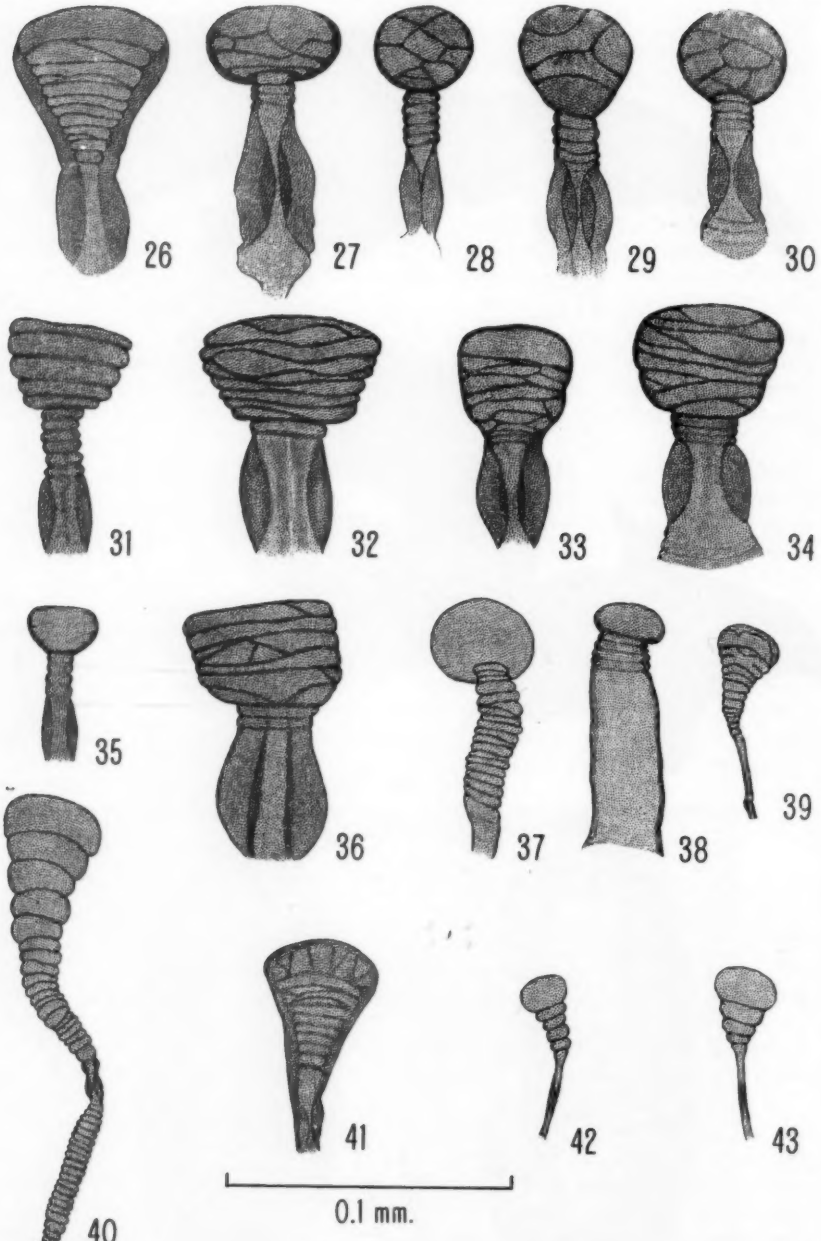
Buccopharyngeal armature of last larval instar (Fig. 22) attached to exit end of puparium, about 1.33 mm. long, heavily sclerotized. Mandibular hooks each curving gently antero-ventrally; longer, more slender than those of *D. hamatus*. Distance from anterior tip of hooks to postero-dorsal angle almost twice distance from postero-dorsal angle to ventral projection of hooks. Hooks fused with intermediate region, but showing constriction at point of junction. Length of mandibular hooks plus intermediate sclerite more than half total length of buccopharyngeal armature. Small hypopharyngeal sclerite present. Intermediate sclerite showing definite articulation with basal sclerite. Basal sclerite dividing into two wide, slightly veined, dorsal wings; two shorter, narrower, ventral







Figs. 22-25. 22, 23, Lateral views of buccopharyngeal apparatus of final-instar dipterous larvae: 22, *Neophorocera edwardsii* (Will.); 23, *Spathimeigenia spinigera* Tns. 24, 25, Cocoons of *Neodiprion sertifer* (Geoff.) showing exit holes of parasites: 24, *Diplostichus hamatus* (A. and W.); 25, *S. spinigera.*



Figs. 26-43. Spiracles of final-instar hymenopterous larvae: 26, *Delomerista diprionis* Cush.; 27, *Exenterus canadensis* Prov.; 28, *E. abruptorius* (Thunb.); 29, *E. amictorius* (Panz.); 30, *E. walleyi* Cush.; 31, *Mastrus argeae* (Vier.); 32, *Endasys subclavatus* (Say); 33, *Aptesis indistincta* (Prov.); 34, *A. basizona* (Grav.); 35, *Agrothereutes* sp. possibly *rufopectus* Cush.; 36, Ichneumonid sp. A; 37, *Euceros frigidus* Cress.; 38, *Lamachus* sp.; 39, *Dahlbominus fuliginosus* (Nees); 40, *Eupelmella vesicularis* (Retz.); 41, *Monodontomerus dentipes* (Dalm.); 42, *Tritneptis diprionis* Gah.; 43, *Dibrachys cavus* (Wlkr.).

wings. Anterior dorsal projection present on margin of each dorsal wing; dorsal projection on margin of each ventral wing.

***Spathimeigenia spinigera* Tns.**

Figs. 23, 25

Spathimeigenia spinigera Tns. was recorded (as *S. erecta* Ald.) as a parasite of *N. sertifer* in Ontario by Finlayson and Finlayson (1958a); of *N. americanus americanus* by Hetrick (1941); of *N. lecontei* by Benjamin (1955), Raizenne (1957), and Thompson (1944); and of *N. pinetum, N. pratti banksianae,* and *D. hercyniae* by Raizenne.

Exit hole (Fig. 25) on tip of host cocoon, without cap as in *D. hamatus,* about 2.0 mm. in diameter, with edges tapering to thin edge and curling outward; thick ridge surrounding hole within cocoon. Puparium free within host cocoon; dark reddish-brown in colour; brittle, semi-transparent, lined with very thin, whitish, transparent film. Mature larval hooks at exit end attached to inner surface of puparium.

Total length of buccopharyngeal armature (Fig. 23) about 0.73 mm. Mandibles heavily sclerotized, each broadly rounded antero-dorsally, with projections on posterior dorsal margin, ventral margin. Intermediate region heavily sclerotized, articulating with basal sclerite. Basal sclerite with two short, wide, dorsal wings; two ventral wings, more heavily sclerotized anteriorly, each with two sections, the lower having long transparent tail.

ACKNOWLEDGMENTS

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SUMMARY

Twenty-three species of parasites of *Neodiprion sertifer* (Geoff.) are separated using the host cocoons from which they emerged. The characters used in the key are the size and position of the exit hole, the size, colour and type of cocoon, and the cephalic structure, spiracles, and skin of the last larval instar. Descriptions of the species are given.

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A Portable Mechanical Insect Trap

By C. F. NICHOLLS[1]

A trap for flying insects that incorporates some of the principles described by Williams and Milne (1935) and Chamberlin and Lawson (1940) was constructed. It consists basically of two conical nets that rotate in a horizontal plane around a central axis that is driven by an electric motor through a series of pulleys. The efficiency of the trap is not affected by wind as an increased airflow through one net is balanced by a decreased airflow through the other. It is green in colour to blend with its surroundings. The trap (Fig. 1) is 5½ feet high at the centre. It has three main sections (Fig. 2): the framework, the driving mechanism, and the nets.

The framework (Fig. 1) is made mainly from ¾-inch aluminum tubing but the 26-inch cross member (1) and the column (H) are made of iron water-pipe. The four arms (J), each 48 inches long, are hinged to the ends of the cross member. Their outer ends (K) are drawn together and secured to short pieces of tubing. These pieces extend two inches beyond the ends of the arms to provide sockets for the net-hoops. The hoops are made of ⅛-inch by one-inch spring aluminum bolted to T shaped brass fittings. Separate tubes (L), six feet long, support the apices of the nets. Telescopic braces (M) are each made from two pieces of tubing ¾ inch and one inch in diameter respectively. These permit the operation of the nets individually at heights of four to eight feet. Heights of eight to 12 feet may be obtained by adding a four foot extension to the column (H).

The driving mechanism (Fig. 3) consists of a series of V-belt pulleys driven by a quarter-horsepower, 1725-R.P.M., electric motor that is protected by a metal rain-shield. The mechanism is mounted on a plywood base, 45 by 32 inches. The variable-pitch pulley (A) has an adjustable diameter of 2.7 to 3.9 inches. Pulley B, ⅝ inch wide by 19 inches in diameter, and pulley C, ½ inch wide by two inches in diameter, are fastened together to form a single step-pulley and are fitted to a shaft. The shaft is welded to a piece of boiler plate that is bolted to the base through slotted holes to permit belt adjustment. Pulley D, similar to B, is mounted in the same way as the step-pulley. The effective diameters of pulleys B and D are reduced to 18.6 inches as ½-inch belts are used in the 5/9-inch grooves. A disc of ¾-inch plywood (E), and a ¾-inch pipe-flange (F) are bolted to pulley D. The pipe-flange provides the socket into which the framework column (Fig. 1, H) is threaded. A brass sleeve (Fig. 3, G) and iron braces steady the column. Lubrication for the column and pulleys is provided through grease cups.

The conical nets, 30 inches long and 20 inches in diameter at the mouth, are of 24-mesh nylon material reinforced at each end. Rubberized cotton sieves of ½-inch mesh can be fastened near the mouths of the nets to exclude large insects. The nets are fastened to the hoops with nylon ties that permit easy removal. The apex of each net is tied to a copper funnel (Fig. 4, N) which has a ⅝-inch-diameter tube leading into a 32-ounce polyethylene bottle (Q). The screw cap of the bottle is held by a copper cylinder (O) attached to the funnel. A hole, 2½ inches in diameter, cut in the bottom of the bottle is covered with a piece of 32-mesh plastic screen held in place with a polyethylene band (R).

The nets revolve through a circle that has a maximum diameter of 9 feet 11 inches. As the height of the nets is changed the diameter and the circum-

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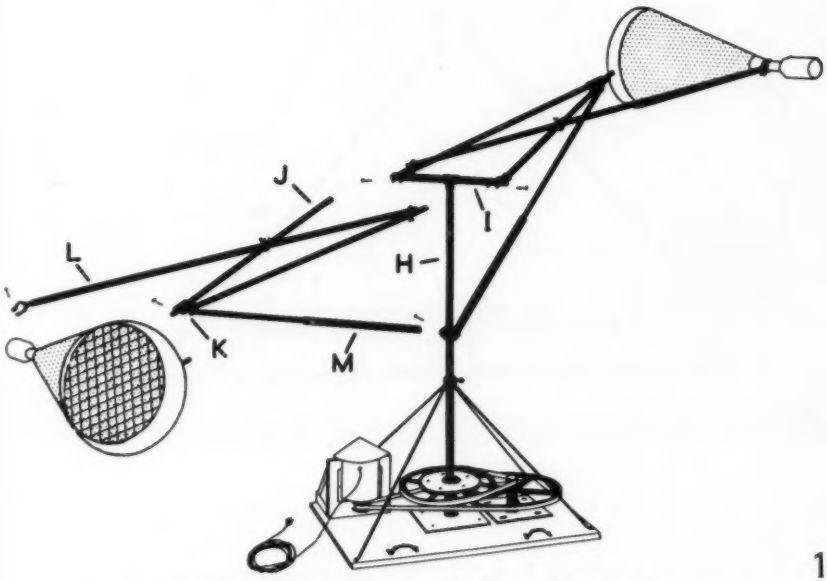

Fig. 1. Diagram of trap showing framework assembly.

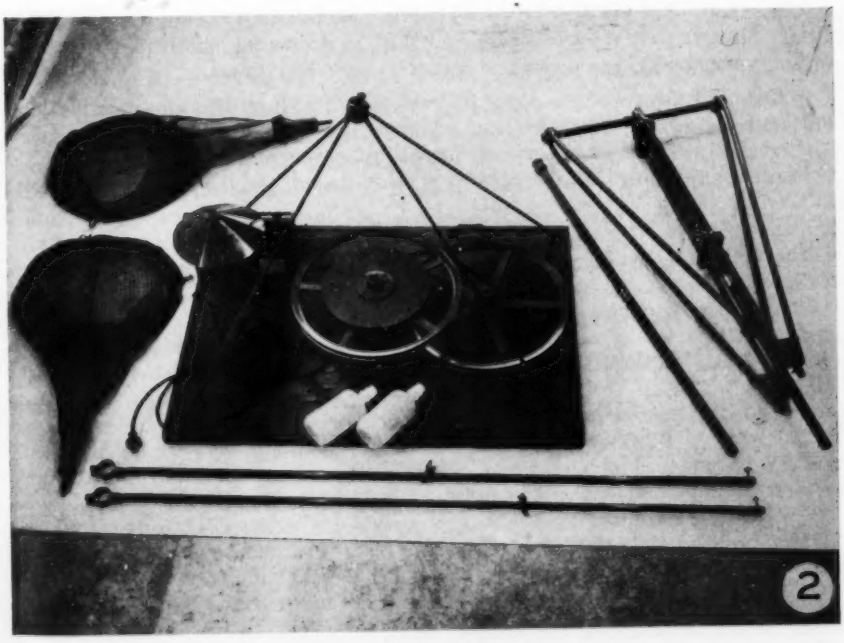

Fig. 2. Disassembled parts.

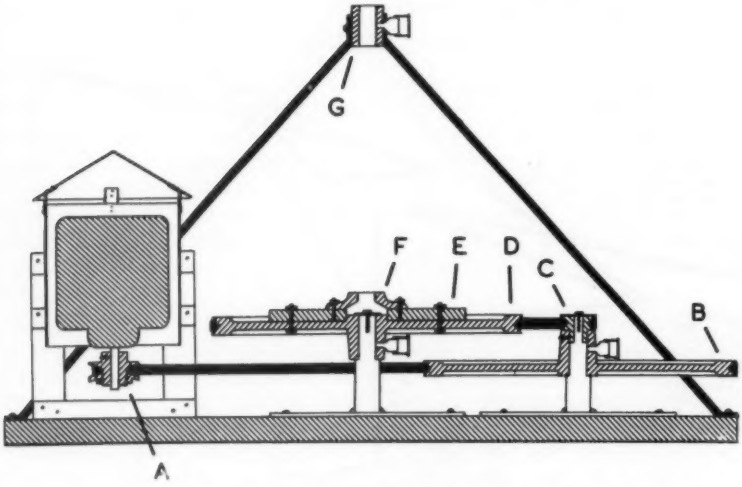

Fig. 3. Sectional drawing of driving mechanism.

ference of the circle (Table I) are also changed. Consequently a change in the number of revolutions per minute must be made to maintain the nets at a constant speed in feet per minute. Table I shows the required number of revolutions per minute at various speeds and heights within the limits of the trap. Pulley A (Fig. 3) is adjusted to produce the required number of revolutions per minute.

A great variety of insects were caught with this trap during the summer of 1958. Diptera were most common, followed, in decreasing numbers, by Homoptera, Hymenoptera, Lepidoptera, Coleoptera, and Hemiptera.

A trap of this type has several desirable features: it enables continuous sampling in the absence of the operator, which is especially important where insects such as mosquitoes are attracted to humans; quantitative data are provided as the volume of air sampled can be calculated from the area of the opening of the net

Table I

Revolutions per minute of nets at various speeds and heights

Height in feet	without extension	4 and 7	5 and 6	8
	with extension	8 and 11	9 and 10	12
*Circumference in feet		29.8	30.9	26.7
Speed in feet per minute				
1100			35.6	
1050		35.2	34.	
1000		33.5	32.4	
950		31.8	30.7	35.6
900		30.2	29.1	33.7
850		28.5	27.5	31.8
800		26.8		30.
750				28.1
700				26.2

*Circumference of circle through which nets rotate.

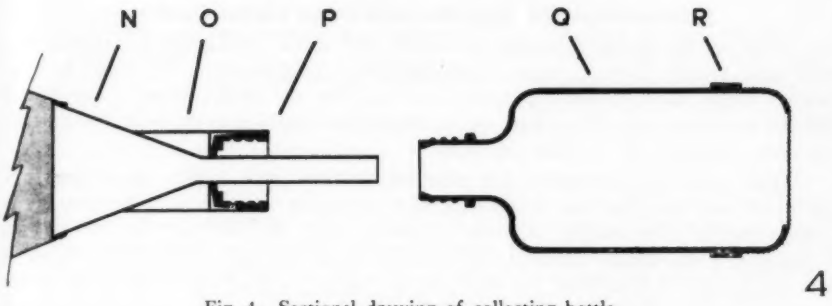

Fig. 4. Sectional drawing of collecting bottle.

and the rate of travel; ample power is provided to eliminate interference by wind; and the trap is easily dismantled, moved, and re-erected. A small gasoline motor could be used where electricity is not available. Materials for the trap were easily obtained at a cost of about 125 dollars.

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A New Species of *Leucopis (Leucopella)* from Chile and a Key to the World Genera and Subgenera of Chamaemyiidae (Diptera)

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This paper contains a description of a species of *Leucopis* Meigen, subgenus *Leucopella* Malloch (1927), and a note on occurrence of the subgenus in the New World (previously known only from Africa). Also a key is given to all the known genera and subgenera of the Chamaemyiidae.

Since the larvae of *Leucopis* species, generally, are predators of aphids and scales, the new species is at least a potential agent for biological control of certain of these insects. That it is a coccid predator is suggested by the fact that two African members of the sub-genus—*Leucopella africana* Malloch and an undescribed species of which I have a single female (reared ex mealybug material from Cape Town, South Africa, intercepted at Riverside, Calif., Aug. 4, 1924)—were reared from mealybugs.

There was previously no key to all the chamaemyiid genera and subgenera. Moreover, in the keys that were available the authors' concepts of some of the groups often differed; this has given rise to much taxonomic confusion in the family. To clarify the situation, I have listed in the key the type species and type designation for each of the genera and subgenera recognized.

The term *proscutellum* is applied to a small, lens-shaped "bump" immediately cephalad of the scutellum (Fig. 1, p); to my knowledge this rather distinctive morphological feature has not been mentioned previously. It appears to be present in most Chamaemyiidae except the genera *Cremifania* Czerny and *Lipoleucopis* de Meijere.

Relationships of *Leucopella* with Other Chamaemyiidae

Flies of the genus *Leucopis* are small and stocky (like many chloropids), and they usually have a densely grey-pollinose integument. The head is high with a large, setulose lunule; postvertical bristles are undeveloped. Propleural bristles are absent but there are two or three postsutural dorsocentral bristles that become progressively weaker cephalad.

The subgenus *Leucopella* has all these features and, unlike any other subgenus of *Leucopis*, has one or more bristles or setulae near the hind margin of the mesopleuron. Prescutellar acrostical bristles may or may not be developed. *Leucopis* (*Leucopella*) *africana* Malloch, the type and only described species of the subgenus, is described by Malloch as having a pair of weak prescutellar acrosticals; these bristles are also weakly present on the single female from Cape Town, but they are undifferentiated in the Chilean representative described below. Concerning the significance of these bristles, like Sabrosky (1957) I "cannot believe that the two species before me belong in different subgenera on the basis of that character alone".

The presence of reclinate ocellar bristles in the female may prove to be a sex-linked character of the subgenus. The character is not mentioned by Malloch (*op. cit.*), apparently because he did not have a female of *L. africana*. However, these bristles are well developed in the African female mentioned above. Moreover, the male of the new Chilean species has relatively strong setulae in the position of the ocellar bristles – a characteristic of males of many species in the *Leucopis ocellaris* group, in which only the females have ocellar bristles. These facts suggest that females of *L. chileana* n.sp. and perhaps of all *Leucopella* species have ocellar bristles.

Neoleucopis Malloch and *Xenoleucopis* Malloch are two other subgenera of *Leucopis* that have ocellar bristles; in both these cases, however, they are equally developed in the two sexes.

Therefore, *Leucopella* shares certain critical chaetotactic characters with *Neoleucopis*, *Xenoleucopis* and the *Leucopis ocellaris* group. Clearly, there is a close phyletic relationship between these groups and *Leucopella* but the presence of mesopleural bristles in the latter indicates a rather strong divergence from all of the former groups, a divergence of sufficient magnitude to warrant separate subgeneric status for *Leucopella*.

Mesopleural bristles are also present in the genera *Paraleucopis* Malloch, *Pseudodinia* Coquillett, and *Cremifania* Czerny but these three genera have a small, bare lunule – a character that indicates they belong in an entirely different branch of the family.

The key provided below separates the various chamaemyiid genera and subgenera and helps to clarify the systematic position of *Leucopella* in the family.

Key to Genera and Subgenera of Chamaemyiidae

1. Lunule bare, usually narrow (from anterior to posterior margins) and inconspicuous; frons usually not emarginate anteriorly; frontal orbit with one or more strong bristles except in *Paraleucopis* 2
   Lunule setulose, wide, and exposed; frons emarginate anteriorly; frontal orbit without bristles except in *Melaleucopis* (strong), *Xenoleucopis* and *Leucopis ocellaris* group (weak) 13
2. Postvertical bristles absent; mesopleuron with some fine hairs or with a strong bristle 3
   Postvertical bristles present; mesopleuron with or without bristles 4
3. Frontal orbit with two bristles; pteropleuron with one or more fine bristles; dull greyish-pollinose species with a yellowish pleural stripe ..... genus *Cremifania Czerny* (1904 : 169)

[Type of genus, *Cremifania nigrocellulata* Czerny (1904), by monotypy]
Frontal orbit and pteropleuron bare; shining black or blue-black species without a pleural stripe ..... genus *Paraleucopis* Malloch (1914: 148)
[Type of genus, *Paraleucopis corvina* Malloch (1914), by original designation and by monotypy]

4. Presutural dorsocentral bristles absent 5
Presutural dorsocentral bristles present 7

5. Mesopleuron with one or more bristles posteriorly; prescutellar acrostical bristles absent ..... genus *Pseudodinia* Coquillett (1902 : 187)
[Type of genus *Pseudodinia varipes* Coquillett (1902), by original designation]
Mesopleuron bare; prescutellar acrostical bristles present 6

6. Frontal orbit with two bristles ..... genus *Pseudoleucopis* Malloch (1925 : 93)
[Type of genus, *Pseudoleucopis magnicornis* Malloch (1925), by original designation]
Frontal orbit with one bristle ..... genus *Chaetoleucopis* Malloch (1932 : 216)
[Type of genus, *Chaetoleucopis dactylopivora* Malloch (1932), by orginal designation and by monotypy]

7. Postvertical bristles divergent; mesonotum with 2 + 3 dorsocentral bristles; mesopleuron with at least one bristle ..... genus *Sciochthis* Malloch (1933 : 381)
[Type of genus *Sciochthis uniseta* Malloch (1933), by original designation and by monotypy]
Postvertical bristles convergent; either mesonotum not with 2 + 3 dorsocentral bristles or mesopleuron bare 8

8. Mesonotum with 1 + 2 dorsocentral bristles 9
Mesonotum with 1 + 3 (2 + 4 in some *Acrometopia* spp.) dorsocentral bristles 10

9. Body wholly shining black; abdomen without spots ..... genus *Melanochthiphila* Frey (1958 : 28)
[Type of genus, *Melanochthiphila nigroaenea* Frey (1958), by monotypy]
Body dull, usually grey-pollinose; abdomen usually with paired black spots ..... genus *Chamaemyia* Meigen (1803 : 278)
[Type of genus, *Chamaemyia elegans* Panzer (1809 : 12), the first included species]

10. Mesopleuron with at least one bristle ..... genus *Parochthiphila* Czerny (1904 : 169)
[Type of genus, *Ochthiphila spectabilis* Loew (1858 : 220), by designation of Czerny (1936 : 22)]
Mesopleuron bare 11

11. Head acutely pointed anteriorly; compound eye attenuated anteriorly, longer than high; frons, above base of each antenna with a group of strong, proclinate setulae; prescutellar acrostical bristles present; wing usually patterned ..... genus *Acrometopia* Schiner (1862 : 434)
[Type of genus, *Oxyrhina wahlbergi* Zetterstedt (1846 : 1954), by designation of Coquillett (1910 : 503)]
Head usually obtusely rounded anteriorly; compound eye usually at least as high as long; proclinate setulae above base of antennae, if present, weak; prescutellar acrosticals undeveloped; wing never patterned (If head rather pointed, eye longer than high and antenna pale yellow, see *Plunomia elegans* Curran) 12

12. Frons with a dark cross-band; lower orbital bristle nearer to upper orbital than to lunule; abdomen of the two sexes with paired dots ..... genus *Euestelia* Enderlein (1927 : 108)
[Type of genus, *Ochthiphila coronata* Loew (1958 : 221), by original designation]
Frons without a transverse band; lower orbital arising nearer to lunule than to upper orbital; abdomen with paired transverse bands in female, paired transverse spots in male ..... genus *Plunomia* Curran (1934 : 365)
[Type of genus, *Plunomia elegans* Curran (1934)[1] for *Chamaemyia elegans*, Malloch (1921 : 347) *nec* Panzer (1809 : 12) = *Plunomia flavicornis* Malloch (1940 : 270)]

13. Proscutellum absent; costa ending at R 4 + 5 ..... genus *Lipoleucopis* de Meijere (1928 : 45, 76)
[Type of genus, *Lipoleucopis praecox* de Meijere (1928), by monotypy]
Proscutellum present; costa attaining M 14

[1]This binomen is in accordance with Art. 16, Sect. 2(C), 1 and 2, of the draft of the Code of Zoological Nomenclature adopted by the Fifteenth Congress of Zoology in 1958 (London Draft).

14. Discal and second basal cells confluent, only a stub of a cross-vein present; head, thorax, and abdomen subshining black; frontal orbit with a strong bristle (subequal to inner vertical bristle) ..... genus *Melaleucopis* Sabrosky (1957 : 114)
[Type of genus, *Melaleucopis orthezíavora* Sabrosky (1957), by original designation]
Discal and second basal cells separate; head, thorax, and abdomen mostly densely covered with cinereous-grey pollen ..... genus *Leucopis* Meigen (1830 : 133) 15
[Type of genus, *Leucopis griseola* (Fallén) (1823 : 4) OR *Leucopis griseola*, Meigen (1830 : 134) *nec* Fallén (1823)[2], the first species, selected by Blanchard (1840 : 627)]

15. Mesopleuron with one or more bristles and/or setulae ..... subgenus *Leucopella* Malloch (1927 : 576)
[Type of subgenus *Leucopis* (*Leucopella*) *africana* Malloch (1927), by original designation and by monotypy]
Mesopleuron bare 16

16. Prescutellar acrostical bristles present 16
Prescutellar acrostical bristles absent 18

17. Mesonotum without a sublateral vitta; ocellar bristles present; larvae associated with adelgids ..... subgenus *Neoleucopis* Malloch (1921 : 357)[3]
[Type of subgenus, *Leucopis* (*Neoleucopis*) *pinicola* Malloch (1921) by original designation and by monotypy]
Mesonotum with a sublateral vitta; ocellars usually absent[4]; larvae associated with scale insects ..... subgenus *Leucopomyia* Malloch (1921 : 355)
[Type of subgenus, *Leucopis* (*Leucopomyia*) *pulvinariae* (Malloch (1921), by original designation and by monotypy]

18. Ocellar plate expanded and usually densely pilose; posterior ocelli usually much farther from each other than from the anterior ocellus; ocellar bristles absent in male, usually present but weak in female ..... *Leucopis ocellaris* group
Ocellar plate not expanded or densely pilose; ocelli forming a nearly equilateral triangle (In some species of *Leucopis* sens. str. a velvety pad, partially enclosing the ocellar triangle gives the illusion of an expanded ocellar plate; but the ocelli are arranged in a nearly equilateral triangle) 19

19. Ocellar bristles absent; never with orbital bristles or setulae ..... subgenus *Leucopis* Meigen (1830 : 133)[5]
[Type of subgenus, see under genus *Leucopis* Meigen above]
Ocellar bristles present, although sometimes weak, frontal orbit usually with two weak bristles ..... subgenus *Xenoleucopis* Malloch (1933 : 384)
[Type of subgenus, *Leucopis* (*Xenoleucopis*) *cilifemur* Malloch (1933) by original designation]

Leucopis (Leucopella) chileana, new species

(Figs. 1-5)

Male.—Head (Fig. 1) about twice as high as long. Frons in the middle more than one-third as wide as head (3:7); distinctly narrower at vertex than at lunule; densely, finely, and uniformly setulose; frontal vitta dark grey-pol-

[2]The type species was misidentified. According to the two specimens bearing the number 2516 in the Meigen Collection in the Paris Natural History Museum, Meigen misidentified his specimens as of *Leucopis griseola* (Fallén). Therefore, the type must be designated by the Commission on Zoological Nomenclature. However, *L. griseola* (Fallén) and *L. griseola*, Meigen, both belong to the subgenus *Leucopis* sens. str., as defined above, and the decision rendered will not change the concept of the genus *Leucopis* sens. lat.

[3]*Leucopiola* Frey (1936 : 102) type *Leucopis hyalipennis* Zett. (1848 : 2715), by original designation is a subjective synonym. I ascertained this by examining two of the three syntypes from Gottland (the series from which Frey selected the lectotype) in the Zetterstedt Collection at Lund, Sweden.

[4]*Leucopomyia luteicornis* Malloch) (1924 : 67), new combination, a coccid predator described from India and originally placed in *Neoleucopis*, has well-developed ocellar bristles. In other morphological and ecological characters, however, it agrees with *Leucopomyia* rather than with *Neoleucopis*.

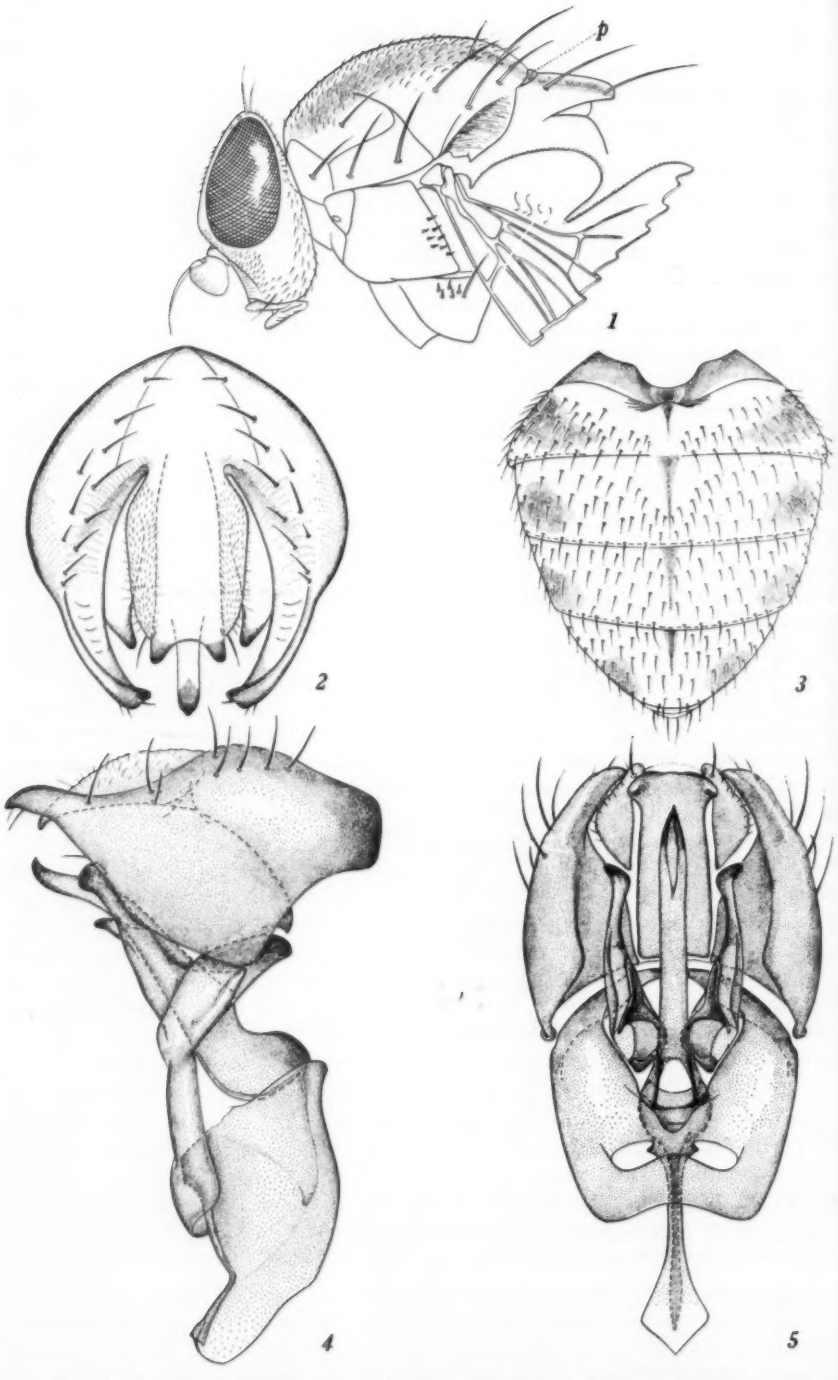
[5]*Chaetoleucopis* Frey (1936: 102) Type, *Leucopis annulipes* Zett. (1848: 2712), by original designation is a subjective synonym. I ascertained this by examining three of the four syntypes of *L. annulipes* in the Zetterstedt Collection at Lund. Also, *Chaetoleucopis* Frey (1936) is a primary homonym of *Chaetoleucopis* Malloch (1932).

linose, paler in the middle; ocellar triangle cinereous-grey, with numerous black setulae encroaching onto it from all sides; parafrontals cinerous-grey with numerous, fine, pale setulae. Inner vertical bristle about two-thirds the length and strength of outer vertical, the latter subequal to anterior notopleural bristle; postvertical bristles undeveloped; postocular setulae small, closely set, and black; ocellar bristles absent. Ocelli forming an equilateral triangle. Lunule highly arched, rather flattened above; with numerous fine setulae similar to those on parafrontals. Cheek very broad, twice as wide as third antennal segment; with one weak genal bristle and numerous, fine, scattered setulae. Parafacial relatively broad; with numerous fine setulae continuous with those of parafrontal and gena. Face cinereous-pollinose, slightly concave in lateral view; antennal fovea rather deep and clearly delimited; facial carina as broad as ocellar triangle. Antenna small; second segment orange-brown, contrasting with the dark third segment; third segment globular, higher than long but about as thick as long, mostly dark brown to black but narrowly orange-brown on inner base. Palpus orange-brown on basal three-fourths, black on apical one-fourth.

Mesonotum cinereous-grey pollinose with a broad, chocolate-brown sublateral vitta extending uninterrupted from inner angle of humerus to apical scutellar bristle (Fig. 1), and a subshining, dark-grey submedian vitta containing a multiserial row of acrostical setulae; sublateral vitta brown, broadest anteriorly, gradually narrowing to its apex; submedian vitta grey, narrowest anteriorly, broadening rather rapidly and fading out on disc of mesonotum. Proscutellum (Fig. 1, p) developed, though not so strongly as in most species of *Leucopis* sens. str. Bristles of mesonotum as follows: one humeral, one posthumeral, two notopleurals, the posterior one slightly weaker, two dorsocentrals, the anterior one much weaker, two postalars, the anterior one weaker, and one postsupraalar; acrostical setulae in two biserial rows anteriorly, becoming quadriserial on disc, and usually extending caudad of strong posterior dorsocentrals; prescutellar acrosticals absent, or at least indistinguishable from acrostical setulae in this area. Scutellum cinereous-grey mesally and laterally; the two brown sublateral vittae converging to the apex and narrowly confluent on the apical declivities. Basal scutellar bristles three-fourths as long as apical ones, the latter more than half as far from each other as from the former. Pleuron cinereous-grey; mesopleuron (Fig. 1) with five to eight fine setulae in middle posterior margin, in two roughly aligned vertical rows; propleuron, pteropleuron, and hypopleuron bare; sternopleuron dorsally with one bristle, preceded by four or five scattered setulae, and ventrally with one relatively weak bristle and three or four setulae.

Legs and tarsi black except as follows: apices and bases of all femora and tibiae, basal halves or less of mid and hind metatarsi. Fore femur of male with an anteroventral row of weak, but not particularly closely spaced, setulae. Mid tibia with a fairly strong apical ventral bristle. Wing membrane whitish, narrowly brown-fumose along the veins; veins dark brown. Penultimate section of fourth vein as long as, or slightly longer than, apical section of fifth, the latter about equal to posterior crossvein. Halteres dull, yellowish-white.

Abdomen (Fig. 3) mostly cinereous-grey with black spots as follows: progressively smaller lateral dots on terga two to four inclusive; elongate-triangular, median spots on terga three and four, and a rather obscure, median vitta on second tergum; third and fourth terga narrowly orange-brown on posterior margins, second with orange-brown limited to margin caudo-laterad of black spots.



Figs. 1-5. *Leucopis* (*Leucopella*) *chileana* n.sp. (Paratype ♂). 1. Left lateral aspect of head and thorax (p = proscutellum). 2. Posterior aspect of genitalia. 3. Dorsal aspect of abdomen. 4. Right lateral aspect of genitalia. 5. Ventral aspect of genitalia.

Genitalia (Figs, 2, 4, 5).—In general, the male genitalia of this representative of the subgenus *Leucopella* does not differ fundamentally from certain representative members of the subgenera *Xenoleucopis* Malloch and *Leucopomyia* Malloch illustrated by Hennig (1941). Some distinctive features include: the fused, ham-shaped, surstylus and epandrium (Fig. 4), the strongly sclerotized, tooth-like apex of each cercus (Figs. 2, 4), the large knobbed postgonite (Figs. 4, 5) and the smaller, simple pregonite (Figs. 4, 5). The aedeagus (Figs. 2, 4) is strongly sclerotized and rather gently curved.

Holotype, ♂, and two *paratypes*, ♂.—Los Martenes, Santiago, Chile; 1400 meters; Sept. 18, 1954; L. E. Peña. Type No. 6815 in the Canadian National Collection.

I have placed the new species in the subgenus *Leucopella* Malloch mainly because it is a *Leucopis* which possesses mesopleural "bristles"—the most important diagnostic character of that subgenus. In addition it agrees well with Malloch's characterization of the subgenus and its general habitus matches that of a single African female before me which represents an undescribed species of *Leucopella*.

Leucopis chileana can be distinguished from *L. africana* Malloch by its hairy parafacial (presumably bare in *africana*), broader cheeks (as wide as third antennal segment in *africana*) darker tibiae and tarsi (mostly yellow in *africana*), and by the greater number of mesopleural setulae [one (or two?) in *africana*].

Summary

A new species, *Leucopis* (*Leucopella*) *chileana*, is described from Chile. The systematic position of the subgenus *Leucopella*, here recorded from the New World for the first time, is discussed, and a key to the world genera and subgenera of the family Chamaemyiidae is provided. Attention is drawn to the presence of a proscutellum (in contrast to a postscutellum) in most groups of Chamaemyiidae.

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Descriptions of Five New Species of Mites from India (Acarina: Phytoseiidae, Aceosejidae)

By D. A. CHANT[1]

The following five undescribed species of mites were collected on citrus trees in the provinces of Assam and Mysore in India by Dr. C. A. Fleschner of the Citrus Experiment Station, Riverside, California. These mites are of the suborder Mesostigmata and are probably predacious. They may be introduced to California in attempts to control phytophagous mites on citrus and, therefore, may be recorded from this state in the future. I am grateful to Dr. Fleschner for the opportunity to examine this material.

The families and genera to which these mites belong were adequately defined by Evans (1958) and Chant (in press).

Phytoseiidae

Typhlodromus (Amblyseius) salebrosus, sp. n.

Figs. 1-4

Female.—Length 425 μ; width 300 μ. Dorsal shield with 15 pairs of setae, nine in the lateral, two in the median, and four in the dorsal rows (Fig. 1). Setae D_3 and D_5 absent. Setae D_2, D_4, D_6, M_1, and L_5 minute. Seta L_1 longer than D_1; L_2 shorter than L_3. Setae L_4, L_9, and M_2 very long, not whip-like. Seta L_6 much longer than L_5; L_7 and L_8 equal. Dorsum heavily sclerotized, faintly marked with crescentic depressions. Lateral margins of dorsal shield curving ventrally.

Setae S_1 and S_2 on interscutal membrane. Sternal shield wide, smooth, with anterior margin deeply excavated, and with three pairs of setae. One pair of metasternal plates, each with a seta. Genital shield wide, truncate posteriorly, sculptured, and with one pair of setae. Peritremal plate very broad posteriorly, where it is sub-divided into three platelets, fused with exopodal plate posteriorly and with dorsal shield anteriorly. Peritreme extending to level of D_1. Ventri-anal shield (Fig. 2) much wider (240 μ) than long (165 μ), heavily sculptured, with three pairs of preanal setae and a pair of pores. Three pairs of setae on

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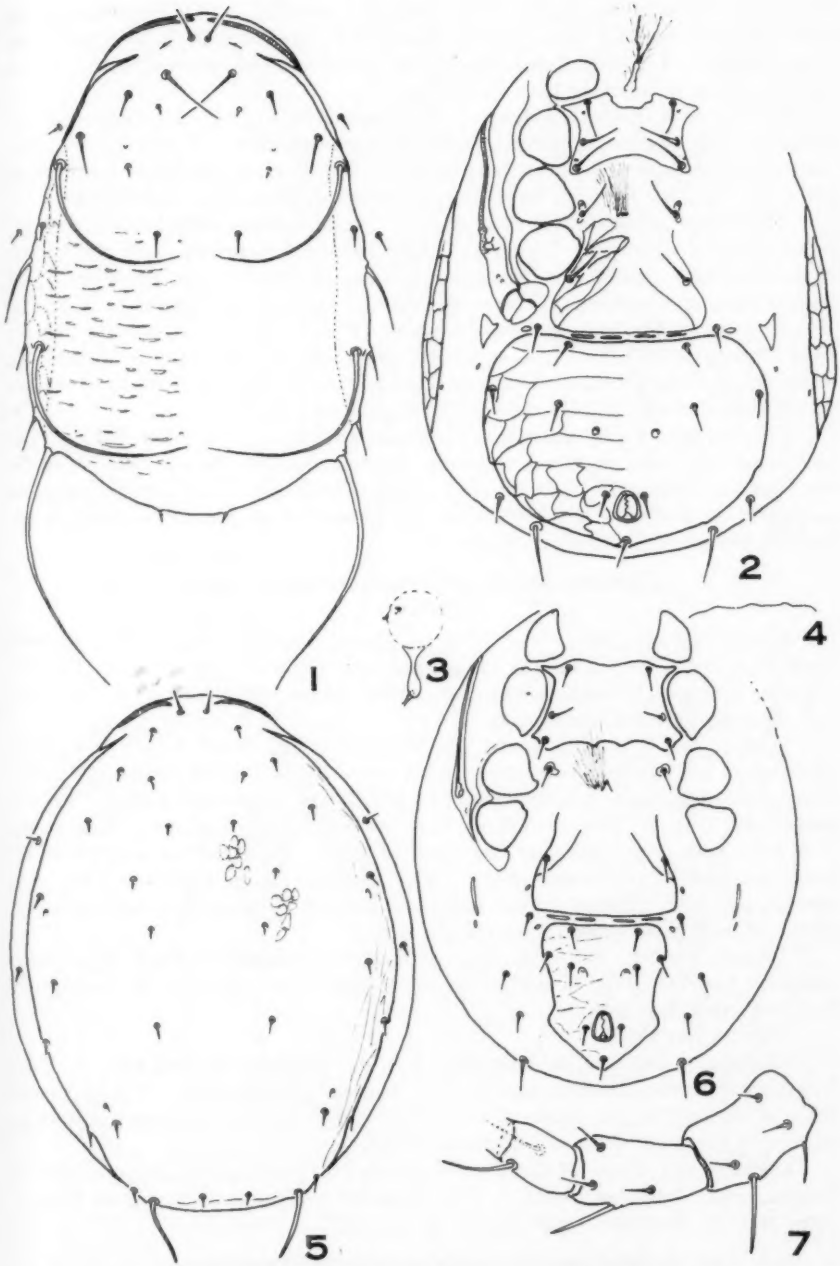


Figs. 1-4. *Typhlodromus* (*Amblyseius*) *salebrosus* sp.n. female. 1, dorsal shield; 2, ventral surface; 3, coxal gland; 4, tectum.

Figs. 5-7. *Typhlodromus* (*Amblyseius*) *assamensis* sp.n. female. 5, dorsal shield; 6, ventral surface; 7, leg IV.

membrane surrounding shield. Four elongate platelets lying between genital and ventrianal shields. Two pairs of metapodal plates, one large, triangular, the other minute. Two additional platelets on posterior, ventral membrane. Coxal gland bulbous at juncture with duct (Fig. 3).

Rostral setae normal in length. Tectum as in Fig. 4. Movable digit of chelicera with two or three teeth; fixed digit multidentate. Tarsus I with setae very long; tarsus II with setae short, peg-like; leg III with two short macrosetae, genu and tibia; leg IV with three short macrosetae, genu, tibia, basi-tarsus.

Male.—Chelicera with spermatodactyl. Sterniti-genital shield heavily sculptured. Leg II unarmed. Ventrianal shield heavily sclerotized, with three pairs of preanal setae arranged in triangular fashion, and with a pair of pores. One pair of setae on membrane surrounding shield. Dorsum and legs as in female.

Diagnosis.—This species resembles both *T.* (*A.*) *septus* (Garman) and *T.* (*A.*) *okanagensis* Chant. It is separated from both by the extreme width and sculpturing of the genital and ventrianal shields, by the excavated anterior margin of the sternal shield, and by the relative lengths of setae L_1 to L_4.

Locality and Type Material.—The holotype female, two other females, and two males, collected on citrus at Jarhat, Assam, India, on March 1, 1959, are in the Canadian National Collection (No. 7004) at Belleville. One female, collected as above, on February 12, 1959, is in the collection of the Citrus Experiment Station, Riverside, California.

Typhlodromus (*Amblyseius*) *assamensis*, sp. n.

Figs. 5-7

Female.—Length 360 μ; width 270 μ. Dorsal shield smooth, with 17 pairs of setae, nine in the lateral, two in the median, and six in the dorsal rows (Fig. 5). All setae except L_9 minute, L_9 40 μ long, thick. Setae L_1 to L_4 much shorter than half distance between their bases.

Setae S_1 and S_2 on interscutal membrane. Sternal shield normal for genus. One pair of metasternal plates, each with a seta. Genital shield normal for genus. Two pairs of elongate platelets between genital and ventrianal shields. Ventrianal shield (Fig. 6) longer (100 μ) than wide (85 μ), of characteristic shape, with three pairs of preanal setae and a pair of pores. Four pairs of setae on membrane surrounding ventrianal shield. Two pairs of metapodal plates, one long, slender, the other minute. Two additional platelets on posterior, ventral membrane. Coxal gland minute, not clearly seen.

Tectum smooth. Movable digit of chelicera unidentate; fixed digit multidentate. Leg IV (Fig. 7) with three short macrosetae, genu, tibia, basi-tarsus. Setae on other legs short.

Male.—Unknown.

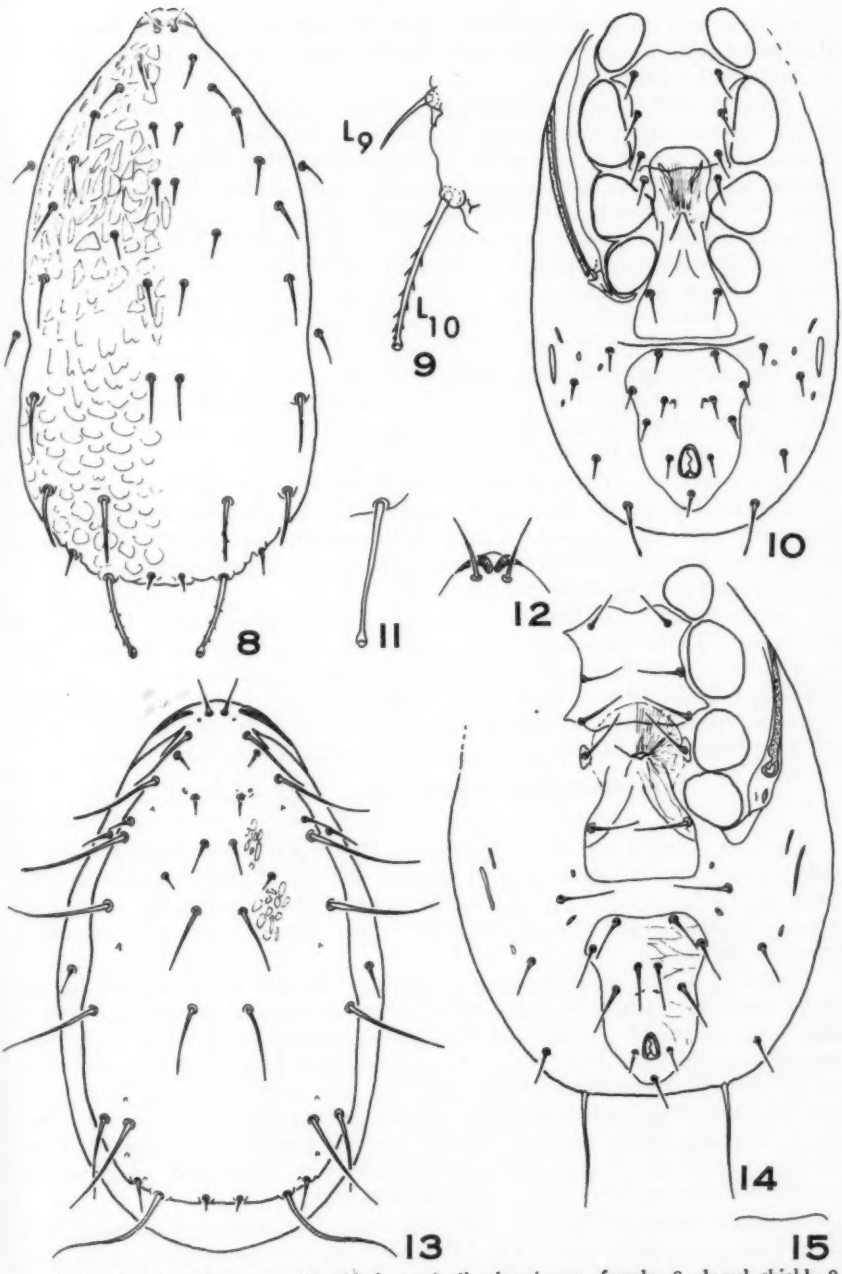
Diagnosis.—This species resembles *T.* (*A.*) *paspalivorus* DeLeon, *T.* (*A.*) *longilaterus* Athias-Henriot, and *T.* (*A.*) *marinus* (Willmann). It is separated from all of these by the shape of the ventral shield and by the length of seta L_9 relative to the other setae on the dorsal shield.

Locality and Type Material.—The holotype female, collected on citrus at Jarhat, Assam, India, on March 1, 1959, is in the collection of the Citrus Experiment Station, Riverside, California.

Typhlodromus (*Typhlodromus*) *fleschneri* sp. n.

Figs. 8-12

Female.—Length 325 μ; width 165 μ. Dorsal shield faintly sculptured, with 18 pairs of setae, 10 in lateral, two in median, and six in dorsal rows (Fig. 8).



Figs. 8-12. *Typhlodromus* (*Typhlodromus*) *fleschneri* sp.n. female. 8, dorsal shield; 9, setae L_9 and L_{10}; 10, ventral surface; 11, macroseta on leg IV; 12, anterior tips of peritreme and setae D_1.

Figs. 13-15. *Typhlodromus* (*Typhlodromus*) *rickeri* sp.n. female. 13, dorsal shield; 14, ventral surface; 15, tectum.

Anterior lateral setae short, about equal to distances between their bases. Posterior laterals longer, thicker than anterior ones. Setae M_2 and L_{10} serrated, L_{10} with bulbous tip (Fig. 9).

Setae S_1 and S_2 on interscutal membrane. Sternal shield normal for the genus. Metasternal plates absent, fourth pair of sternal setae on membrane. Genital shield normal for the genus. Membrane between genital and ventrianal shields folded in some specimens. Ventrianal shield slightly longer (90 μ) than wide (83 μ), triangular with anterior margin rounded, and with four pairs of preanal setae and a pair of pores (Fig. 10). Four pairs of setae on membrane surrounding ventrianal shield. Two pairs of slender metapodal plates, one longer. Three additional pairs of platelets on posterior, ventral membrane. Coxal gland small, with basal portion bell-shaped. Distal membranous part apparently absent in this species.

Tectum smooth. Movable digit of chelicera with two teeth; fixed digit impossible to examine. Leg IV with three macrosetae, those on genu and tibia short, that on basi-tarsus longer (Fig. 11), each with tip bulbous. Peritreme extending to level of seta D_1, with recurved tip (Fig. 12).

Male.—As in *T.* (*T.*) *rhenanus* (Oud.) except setae are knobbed as in female.

Diagnosis.—This species closely resembles *T.* (*T.*) *rhenanus* but is separated from it by the bulbous tip on seta L_{10} and the macrosetae on leg IV, by the shape of the ventrianal shield (in *rhenanus* this is more angular anteriorly), and by the recurved anterior tips of the peritremes.

Locality and Type Material.—The holotype female, two other females, and one male, collected on orange leaves at Mercara, Coora District, Mysore, India, on February 1, 1959, are in the Canadian National Collection (No. 7005) at Belleville. Three females from citrus, Shillong, Assam, one female from citrus, Burnihat, Assam, and one female from lemon leaves, Bangalore, India, are in the collection of the Citrus Experiment Station, Riverside, California.

Typhlodromus (Typhlodromus) rickeri sp. n.

Figs. 13-15

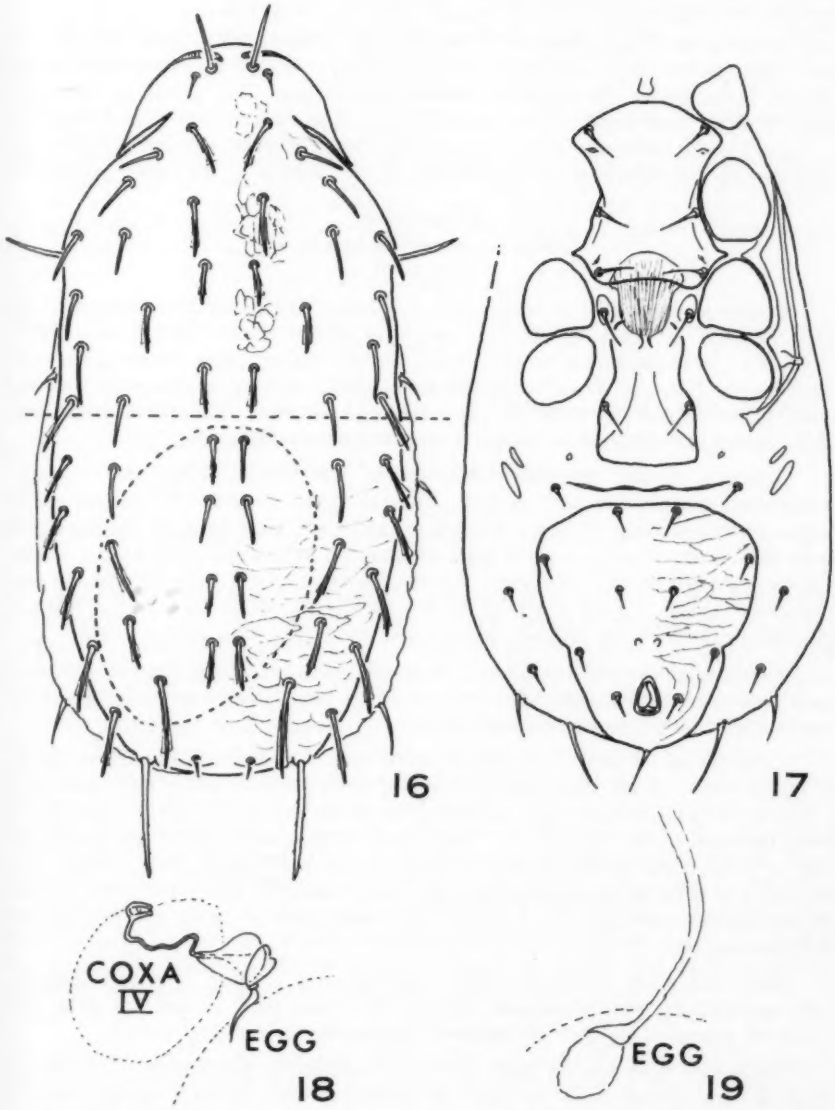
Female.—Length 365 μ; width 180 μ. Dorsal shield smooth, and with 18 pairs of setae, 10 in lateral, two in median, and six in dorsal rows (Fig. 13). Setae L_1, L_3, L_5, L_6, L_7, L_8, L_{10}, D_4, D_5, and M_2 long, remaining setae short. Seta L_4 slightly longer than L_2. Seta L_1 longer than D_1. Six pairs of minute pores on shield.

Setae S_1 and S_2 on interscutal membrane. Sternal shield normal for the genus with three pairs of setae. One pair of metasternal plates, each with a seta. Genital shield normal. Membranous extension from vulva lying over posterior margin of sternal shield. Ventrianal shield longer (125 μ) than wide (85 μ), constricted to form a waist, and with four pairs of preanal setae and a pair of pores (Fig. 14). Four pairs of setae on membrane surrounding shield, one, VL_1, long. Two pairs of slender metapodal plates, one longer. Three additional platelets on posterior ventral membrane. Peritremal plate normal, peritreme extending anteriorly to level of seta D_1.

Tectum smooth (Fig. 15). Movable digit of chelicera unidentate; fixed digit without apparent teeth. Leg IV with three long macrosetae, genu, tibia, basi-tarsus. Setae on all coxae longer than usual for the genus.

Male.—As in *T.* (*T.*) *contiguus* Chant. Macrosetae shorter than in female.

Diagnosis.—This species resembles *T.* (*T.*) *contiguus*, known from Hong Kong, the taxonomic significance of which was emphasized in an earlier paper



Figs. 16-19. *Lasioseius quadrisetosus* sp.n. female. 16, dorsal shield; 17, ventral surface; 18, 19, coxal glands.

(Chant, 1959). *T.* (*T.*) *rickeri* sp.n. is separated from *contiguus* by having two additional lateral setae on the dorsal shield (L_5 and L_8), by the shape of the ventrianal shield (rectangular in *contiguus*), by the dentition of the chelicerae, and by the length of setae D_3 to D_5 (minute in *contiguus*).

Locality and Type Material.—The holotype female, three other females, one male, two protonymphs, and three deutonymphs, collected on citrus at Shillong, Assam, India, are in the Canadian National Collection (No. 7006) at Belleville. Four females, one male, and a protonymph, from citrus leaves at Bangalore, India, are in the collection of the Citrus Experiment Station, Riverside, California. The species was named in honour of Mr. D. W. Ricker of the latter institution.

Aceosejidae

***Lasioseius quadrisetosus* sp. n.**

Figs. 16-19

Female.—Length 370 μ; width 180 μ. Dorsal shield faintly sculptured, and with 31 pairs of setae, 15 on the "posterior dorsal shield" (see Evans, 1958) (Fig. 16). Five pairs of setae in J series, slightly shorter than distances between their bases. Setae of Z and marginal series about as long as distances between their bases. Posterior setae faintly serrated, all setae somewhat lanceolate. Only three pairs of setae on lateral interscutal membrane.

Jugularia absent. Sternal shield normal for family. One pair of large metasternal plates, each with a seta. Genital shield normal. Ventrianal shield large, as wide as long (115 μ), triangular, and with four pairs of small preanal setae and a pair of pores. Four pairs of setae on membrane surrounding shield. Fold in membrane and two pairs slender, elongate plates between genital and ventrianal shields. Two pairs of broad metapodal plates. Peritreme normal, extending anteriorly to seta D_1, plate fused anteriorly with dorsal shield.

Gnathosoma normal for genus. Tectum smooth. Fixed digit of chelicera multidentate; movable digit with two or three teeth. Legs normal; two short macrosetae on IV (tarsus and basi-tarsus).

Coxal gland variable. In the holotype this is as in Fig. 18; central body of gland with a thick, short duct leading to oviduct (containing egg) and with a slender, sinuous, longer duct extending to what appears to be an opening, or pore, between coxae III and IV. In another female, also gravid, the gland has only a wide, thin walled, duct extending to coxa IV (Fig. 19). These two females are alike in other respects and were collected from the same leaves. In this instance, at least, the form of the coxal gland is of no use for specific characterization.

Male.—All setae on dorsal shield much shorter than in female. Chelicera with spermatodactyl. Ventrianal shield with seven pairs of preanal setae and a pair of pores. One pair of setae on membrane surrounding shield.

Diagnosis.—This species most closely resembles *L. penicilliger* Berl. but is separated by having only 16 pairs of setae on the "anterior dorsal shield"; *penicilliger* has 21 pairs.

Locality and Type Material.—The holotype female, six other females, and a male, were collected on citrus at Burnihat, Assam, India, on February 25, 1959. Four females and the male are in the Canadian National Collection (No. 7007) at Belleville, and the remainder are in the collection of the Citrus Experiment Station, Riverside, California.

Summary

Five new species of phytoseiid and aceosejid mites from India are described and figured. These are: *Typhlodromus* (*Amblyseius*) *salebrosus*, from citrus, Assam; *T.* (*A.*) *assamensis*, from citrus, Assam; *T.* (*T.*) *fleschneri*, from orange leaves, Mysore; *T.* (*T.*) *rickeri*, from citrus, Assam; and *Lasioseius quadrisetosus*, from Assam.

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Taxonomy of the Genus *Cecidomyia* (Diptera: Cecidomyiidae) with Special Reference to the Species Occurring on *Pinus banksiana* Lamb.

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Several species of resin midges (or pine-pitch midges) have been recorded from species of *Pinus* in North America. These are all at present referred to the genus *Retinodiplosis* Kieffer 1912; for reasons given below this genus is here treated as a subjective synonym of *Cecidomyia* Meigen 1803. At least two species of *Cecidomyia* have been recorded from jack pine, *Pinus banksiana* Lamb., in Ontario, Manitoba, Saskatchewan and Michigan (Bradley (1946), Barker and Wong (1948), anonymous (1946), Prentice and Hildahl (1957, 1958) and McDaniel (1938)); they were sometimes determined as *Retinodiplosis* sp., sometimes tentatively or definitely as *R. resinicola* (O.S.). Study of specimens of *Cecidomyia* from *P. banksiana* collected during the past three years by officers of the Forest Biology Regional Research Laboratories, Canada Department of Agriculture, has shown that three species of the genus occur on this host. All three are described as new in this paper. *C. resinicola* (O.S.) 1871, originally described from Virginia pine, *Pinus virginiana* Mill., was not present in this material nor among Michigan specimens from *P. banksiana* in the U.S.N.M.; it almost certainly does not occur on *P. banksiana*.

Generic Synonymy

Kieffer (1912) erected the genus *Retinodiplosis* for *Diplosis resinicola* O.S.; he distinguished it from *Cecidomyia* on the basis of a shorter empodium (not longer than the claws) and the absence of a breastbone and bilobed dorsal tubercles in the larva. Actually, *resinicola* and the other Nearctic species here referred to *Cecidomyia* have the empodium one-third longer than the claws, as has *C. pini* (Deg.) 1782, the type of *Cecidomyia* and apparently the only species at present correctly referred to the genus. The larvae of the Nearctic species are very variable; the breastbone and the dorsal tubercles may be present or absent but other characters (particularly the sclerotized spiracular processes and the

form of the eighth and anal segments) indicate that all species of *Retinodiplosis* except *R. taxodii* Felt 1916 should be included in *Cecidomyia*.

Stelechodiplosis Möhn 1955, based on *S. magna* Möhn, should also be considered a subjective synonym of *Cecidomyia*. The larva differs from that of *C. pini* only in its larger size and longer bristles; the male differs only in having sternite 10 rounded apically instead of emarginate (Möhn, 1955a). *C. albitarsis* (Felt) 1916 also has sternite 10 non-emarginate, and the larvae of many species here referred to *Cecidomyia* differ from the larva of *C. pini* much more than does that of *Stelechodiplosis magna* Möhn. To break into separate genera a group so well defined by adult and larval characters seems unnecessary and undesirable.

Characters of *Cecidomyia*

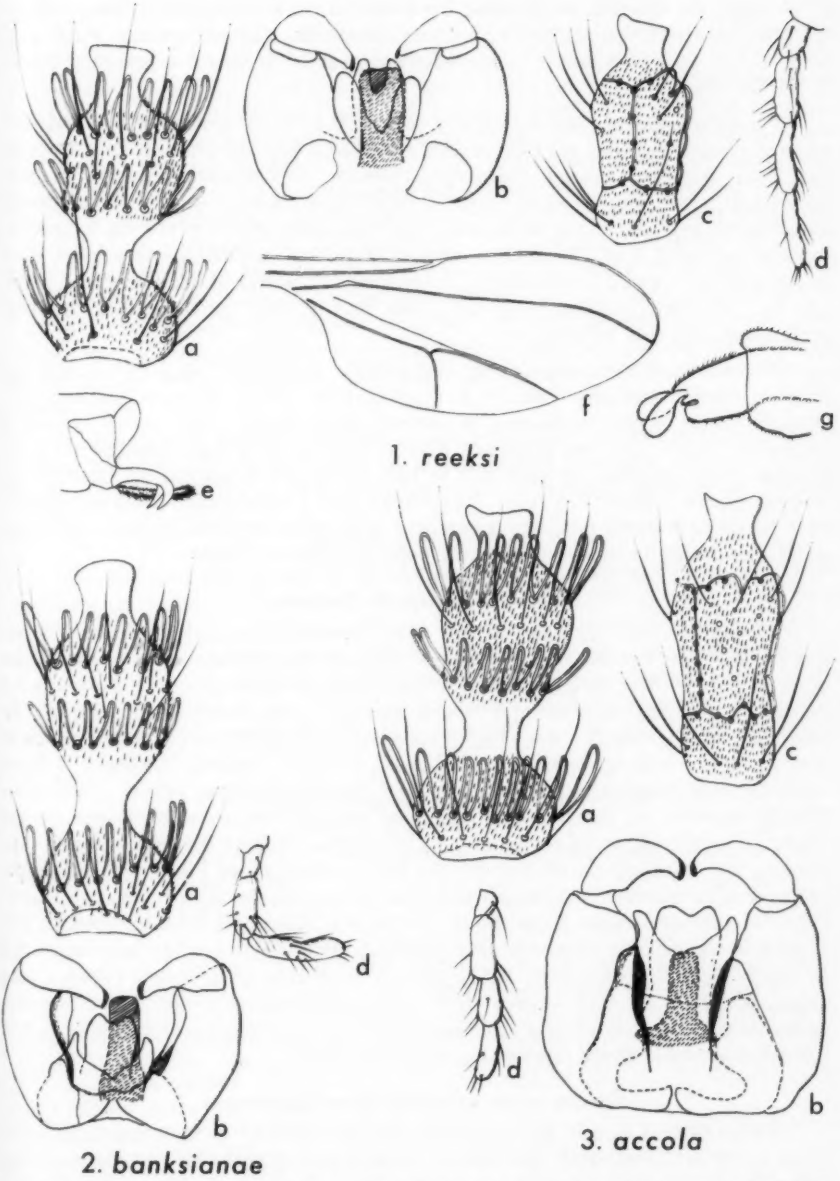
The genus *Cecidomyia* may be characterized as follows:

Adults.—Head as wide as high, widest at one-third its height; eyes broadly confluent above. Antenna with 2 + 12 segments in both sexes; pedicel and scape normal; first and second flagellar segments separate; each flagellar segment with two irregular whorls of bristles. Flagellar segments of males [Figs. 1a, 2a, 3a, 4-8 (a-c)] stalked, each with a shorter basal and a longer apical node, the former with one, the latter with two circumfilae; circumfilae moderately long, regular, each with 18 to 22 closely-placed loops. Flagellar segments of females [Figs. 1c, 3c, 4-7 (d-f)] stalked, nodes very poorly indicated, circumfilae appressed, each segment with two rings and two longitudinal connectives. Palpus (Figs. 1d, 2d, 3d) with three or four segments. Costa ending behind wing apex, weakened at apex of third vein; fourth vein forked (Fig. 1f). Tarsal claws (Fig. 1e) simple, acute, strongly curved, unswollen; empodium one and one-third times as long as claws. Male terminalia (Figs. 1b, 2b, 3b) wider than long; basistyle stout, unlobed; dististyle with hairs or bristles to apex, short, rather stout, straight or slightly curved, sometimes tapering towards apex, with sclerotized, flattened apex which in dorsal or ventral view looks like an apical tooth; tergite 10 broadly and deeply emarginate, the lobes slender and rounded apically; sternite 10 variable in width, rounded apically or with a shallow or deep emargination; aedeagus [style of Foote (1956) and of Felt] smooth, flat, more or less parallel-sided, subtruncate apically; harpes absent. Ovipositor (Fig. 1g) fleshy, retractile, rather short, with elongate-oval cerci.

Pupa.—Antennal horn (Figs. 9h; 10g,h; 11g,h) subacute or rounded, undivided; vertical tubercles (immediately above bases of antennae) simple, each with a vertical bristle (Figs. 9h, 10h, 11h), median vertical process between vertical tubercles present or absent. Prothoracic spiracular horns (Figs. 10i, 11i) smooth, slender, acute, slightly to strongly curved. Abdomen of exuvium hyaline, finely shagreened, without spines or tubercles.

Larva[1] (Figs. 12, 13).—Elongate, tapering anteriorly and posteriorly, not flattened, sometimes strongly tuberculate. Breastbone present or absent. Integument smooth except for setulose bands; transverse setulose bands present on most segments but not on head, collar, prothorax or anal segment, variable in position and extent and in size and colour of setulae; a longitudinal setulose band present on either side of anus. Dorsal head sclerite (a discrete integumentary sclerotization shaped like a curved "X" and lying on the dorsal surface of head and collar (Fig. 9k)) present or absent. Segment 8 (Figs. 12b, 13b) apical,

[1]Terminology from Möhn (1955b), except that abdominal segments 1 to 8 are referred to here as segments 1 to 8.



Figs. 1-3. 1, *Cecidomyia reeksi* n. sp.; 2, *C. banksianae* n. sp.; 3, *C. accola* n. sp. [*a*, fifth flagellar segment, male; *b*, terminalia, male, dorsal (hairs and bristles omitted, aedeagus shaded); *c*, fifth flagellar segment, female; *d*, palpus, male; *e*, tarsal claws and empodium; *f*, wing; *g*, apex of ovipositor].

bilobed posteriorly, each lobe with a stout, heavily sclerotized spiracular process at its apex, the spiracle surrounded by four flattened, blade-like spines. Other spiracles on short, subconical, sclerotized processes, without spines. Anal segment (Figs. 12c, 13c) small, lying posteroventrad of segment 8, scarcely visible in dorsal view.

Thoracic segments and segments 1 to 7 each with six dorsal papillae and two pairs of pleural papillae; segment 8 with two dorsal papillae and one or two pairs of pleural papillae. Dorsal and pleural papillae, except sometimes the median dorsal pair, each with a bristle. Dorsal papillae of thoracic segments and dorsal and pleural papillae of segment 8 not on tubercles; others often on tubercles, those of segments 1 to 7 sometimes minute (Fig. 12a), sometimes very large with dorsal papillae 1 and 2 (and 5 and 6) on a common, partly divided tubercle (Figs. 13a, f). Terminal papillae (Figs. 12d, 13d) four or six, bristled, at least one pair with blunt, peg-like bristle.

Breastbone, when present, long and slender, the anterior end broadened, the anterior margin straight, concave or convex (Fig. 13e). Ventral surface, particularly that of the abdomen, sometimes with many low, broad, rounded tubercles which bear the papillae. Sternal and inner pleural papillae without bristles; lateral papillae on each side in two groups of three, two of each group with a minute bristle (Fig. 13e). Segments 1 to 7 each with four anterior and two posterior ventral papillae; segment 8 with four ventral papillae; two anal papillae, variable in position; all these papillae without bristles.

Hosts of Species of *Cecidomyia*

The species of *Cecidomyia* are, with two exceptions, known only from species of *Pinus;* the larvae either live in exuded resin masses or form pits in the outer layers of new twigs. Barnes (1951) has given an excellent summary of published biological data for the various species. Two European species can be referred to the genus: *C. pini* (Deg.) has been reported from *Picea* and *Abies* as well as from *Pinus sylvestris* L. (see Barnes, 1951), *C. magna* (Möhn) has been recorded only from resin masses of "Fichte" (*Picea*?) (Möhn, 1955a). The conflicting accounts of the biology of *C. pini* suggest that more than one species might be confused under this name. The eight described Nearctic species (including the three described below) are known only from *Pinus*. *C. piniinopis* O.S. (usually written as *C. inopis* O.S.) and *C. resinicola* (O.S.) were both described from specimens from *Pinus virginiana* Mill. (= *P. inops* Ait.); the former has since been recorded from *P. rigida* Mill. (Felt, 1912), the latter from *P. rigida* (Eckel, 1903; Felt, 1911) and *P. banksiana* (McDaniel, 1938). The other six species are each known from only one species of *Pinus*. As it appears probable that the record of *C. resinicola* from *P. banksiana* was erroneous, it is possible that each of the species has only one host.

Species to be excluded from *Cecidomyia*

Retinodiplosis taxodii Felt 1916 has a larva differing in structure and habits from those of *Cecidomyia;* the species should undoubtedly be referred to some other genus, although I cannot say which one. The larva forms a gall (aborted seed?) in the cones of bald cypress, *Taxodium distichum* (L.) Richard; it lacks sclerotized spiracular processes on segment 8 and is smoothly rounded posteriorly (Felt, 1916). I have examined one male from the U.S.N.M. (it is from Charleston, Mo., and is apparently one of the type series); it resembles specimens of *Cecidomyia* but has much more elongate stems on the flagellar segments, the

empodium is only half as long as the claws, and the dististyle is moderately slender and strongly curved. Several other species of gall midges from *Pinus* have been referred to *Cecidomyia;* all of them attack the needles. It is possible that *Cecidomyia brachynteroides* O. S. 1862, *C. baeri* Prell 1931 and *Diplosis pinirigidae* Packard 1890 belong to the genus *Thecodiplosis,* as three species of that genus feed on needles of *Pinus. C. pinifoliae* Felt 1936 cannot be a species of *Thecodiplosis* because the flagellar segments of the male have three circumfilae instead of two; however, as the larva is described as having two fleshy, upturned processes at its posterior end the species cannot be included in *Cecidomyia* as defined here. Two unnamed midges from *Pinus* have also been referred to *Cecidomyia* or *Retinodiplosis.* The species occurring on *Pinus ponderosa* Douglas in the western United States (Evendon, 1935; Austin *et al* 1945) is almost certainly an undescribed species of *Cecidomyia.* The species from *Pinus longifolia* Roxb. in India described by Stebbing (1905) as *Cecidomyia* (?) sp. may possibly be a species of *Cecidomyia,* but the tubercles on the larva, as figured by Stebbing, differ very much in arrangement from those of any species known to me.

Kieffer (1913) included 290 species in *Cecidomyia* but indicated that all but *C. pini* should probably be placed in other genera; the same almost certainly applies to the 50 Nearctic species included in *Cecidomyia* (as *Itonida*) by Felt (1921).

Introduction to Keys

The key to males given below includes all the described Nearctic species certainly referable to *Cecidomyia* except *C. palustris* (Felt) 1915. This species was reared from resin on *Pinus palustris* Mill. in Alabama; I have seen no specimens but it is probably a valid species. The keys to larvae and pupae include all those species of which I had specimens or of which descriptions in the literature were satisfactory. The key to females includes only the species on *Pinus banksiana;* it is probable that the females of many species of the genus will not be separable.

Keys to the Nearctic species of *Cecidomyia*

Larvae

1. Abdominal segments 1 to 7 with long, prominent, bifid, paired dorsal tubercles (Fig. 13a); breastbone present 2
   Segments 1 to 7 with at most minute dorsal tubercles (Fig. 12a); breastbone present or absent 3
2. Segments 1 to 7 each with a pair of small, sub-median, tubercles between the large, bifid, dorsal tubercles (Fig. 13f); head without a dorsal sclerite; transverse setulose bands inconspicuous, the setulae small, pale and sparse; host, *Pinus banksiana* ..... *banksianae* n. sp.
   Segments 1 to 7 without submedian dorsal tubercles; head with a dorsal sclerite (Fig. 9k); transverse setulose bands conspicuous, the setulae large, dark and abundant; host, *Pinus strobus* (L.) ..... *albitarsis* (Felt)
3. Breastbone absent 4
   Breastbone present; host, *Pinus radiata* D. Don. ..... *resinicoloides* Williams
4. Head with dorsal sclerite (as in Fig. 9k); host, *Pinus virginiana* (and *P. rigida*?) ..... *resinicola* (O.S.)
   Head without dorsal sclerite; host, *Pinus banksiana* ..... *reeksi* n. sp.

Pupae

1. Antennal horns (Figs. 9h, 11g, h) subacute, distinct; vertical tubercles (Figs. 9h, 11h) short, with bristle at apex; thoracic respiratory horn (Fig. 11i) short, only very slightly curved 2

Antennal horns (Figs. 10g, h) low, rounded; vertical tubercles elongate, with bristle near base; thoracic respiratory horn (Fig. 10i) long, strongly curved; host, *Pinus banksiana* ..... *reeksi* n. sp.

2. Vertical tubercles separate, with blunt median vertical process between them (Fig. 11h); host, *Pinus banksiana* ..... ***banksianae* n. sp.**

Vertical tubercles partly fused, no median vertical process (Fig. 9h); host, *Pinus strobus* ..... *albitarsis* (Felt)

Males

1. Three palpal segments 2

Four palpal segments 3

2. Fifth flagellar segment with basal stem slightly longer than wide (Figs. 2a, 5b); host, *Pinus banksiana* ..... *banksianae* n. sp.

Fifth flagellar segment with basal stem not more than half as long as wide (Fig. 8b); host, *Pinus virginiana* (and *P. rigida*?) ..... *piniinopis* O.S.

3. Sternite 10 (Figs. 1b, 3b) at least slightly emarginate apically, broader than aedeagus; hind tarsus unicolorous 4

Sternite 10 rounded apically, not broader than aedeagus; hind tarsus with first two segments dark brown, the last three white; host, *Pinus strobus* ..... *albitarsis* (Felt)

4. Sternite 10 deeply emarginate, depth of emargination almost half width of sternite (Fig. 1b) 5

Sternite 10 shallowly emarginate, depth of emargination about one-sixth width of sternite (Fig. 3b) 6

5. Stems of fifth flagellar segment not longer than wide (Figs. 1a, 4b); host, *Pinus banksiana* ..... *reeksi* n.sp.

Stems of fifth flagellar segment 1½ times as long as wide (Fig. 7b); host, *Pinus virginiana* (and *P. rigida*?) ..... *resinicola* (O.S.)

6. Fourth palpal segment more than four times as long as broad; host, *Pinus radiata* ..... *resinicoloides* Williams

Fourth palpal segment less than three times as long as broad; host, *Pinus banksiana* ..... *accola* n. sp.

Key to the females of *Cecidomyia* occurring on *Pinus banksiana*

1. Four palpal segments 2

Three palpal segments ..... *banksianae* n. sp.

2. Longitudinal connective of circumfila with three to five (usually four) points of attachment (Fig. 1c) ..... *reeksi* n. sp.

Longitudinal connective of circumfila with six to eight (usually seven) points of attachment (Fig. 3c) ..... *accola* n. sp.

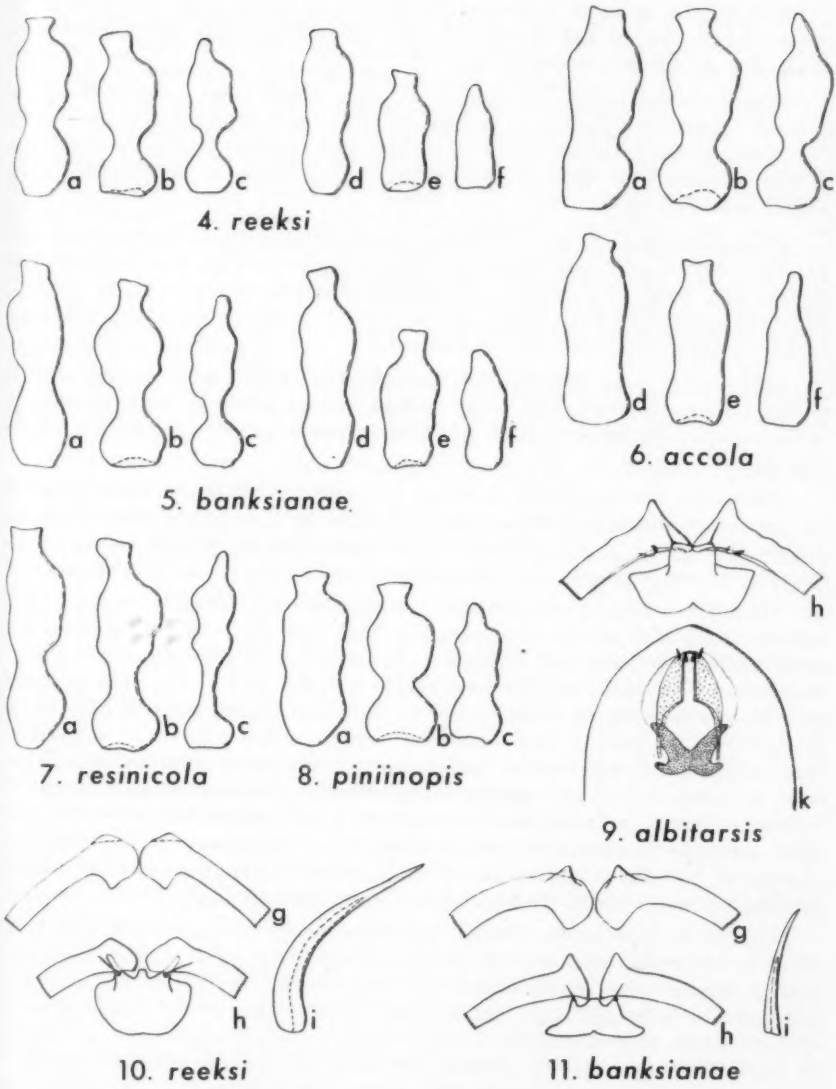
***Cecidomyia reeksi* n. sp.**

Figs. 1, 4, 10, 12

Male.—Wing length 2.4 to 2.9 mm. Head (including antenna and palpus) and thorax brown; abdomen pale yellowish brown, terminalia darker; legs pale brown. (Colour from specimen in alcohol).

Antenna with pedicel about two-thirds as long as and a little narrower than scape; each flagellar segment slightly shorter and more slender and with a better defined proximal stem and a proportionately longer distal stem than the preceding segment, so that the last (Fig. 4c) is about three-fourths as long and wide as the first (Fig. 4a); fifth flagellar segment (Figs. 1a, 4b) with proximal stem a little wider than long and with distal stem about as long as wide; middle circumfila slightly shorter than the other two, each with about 18 loops. Palpus (Fig. 1d) with four segments, the fourth the longest, proportions of segments about 11:25:26:27.

Wing with venation as in Fig. 1f. Hind femur one and one quarter times as long as hind tibia; proportions of hind tarsal segments 1.0:8.1:4.9:3.0:1.4. Claws and empodium as in Fig. 1e.



Figs. 4-11. 4, 10, *C. reeksi;* 5, 11, *C. banksianae;* 6, *C. accola;* 7, *C. resinicola* (O.S.); 8, *C. piniinopis* O.S.; 9, *C. albitarsis* (Felt). [*a, b, c,* outlines of first, fifth and twelfth male flagellar segments respectively; *d, e, f,* outlines of first, fifth and twelfth female flagellar segments respectively; *g,* base of antennal sheaths of pupa, ventral; *h,* head, and base of antennal sheaths of pupa, dorsal; *i,* thoracic respiratory horn of pupa; *k,* head of larva, anterodorsal (head capsule lightly stippled, dorsal head sclerite heavily stippled).]

Terminalia (Fig. 1b) with dististyle stout basally, tapering to rather slender apex; sternite 10 deeply emarginate, depth of emargination nearly one-half width of tergite; aedeagus 0.044 mm. to 0.055 mm. wide, about 0.75 as wide as sternite 10; tergite 10 and sternite 10 with a few very weak bristles and with dense, fine pubescence; aedeagus bare.

Female.—Wing length 3.0 mm. to 3.3 mm. Head, palpi, wings and legs as in male. Flagellar segments as in Figs. 1c, 4d-f, each segment slightly shorter than the preceding; circumfila of two rings and two longitudinal connectives, each connective with three to five (usually four) points of attachment. Ovipositor as in Fig. 1g.

Pupa.—Length 3.0 mm. Antennal horn (Fig. 10g) low, broad, blunt. Vertical tubercle (Fig. 10h) elongate, slender; bristle inserted near base; tubercle beyond seta pale, very lightly sclerotized. Median vertical process present. Thoracic respiratory horn (Fig. 10i) 0.26 to 0.32 mm. long, strongly curved. Abdomen finely and uniformly shagreened.

Larva (Fig. 12a).—Length 3.9 mm. Living larvae bright orange-red in colour. Segments 1 to 7 each with a pair of minute, partly divided, dorsolateral tubercles; spiracles on very weak tubercles; tubercles otherwise absent. Breastbone absent.

Transverse setulose bands abundant and distinct. Dorsally, anterior bands are present on meso- and meta-thorax and segments 1 to 5, posterior bands are present on segments 1 to 7. Ventrally, anterior bands are present on meso- and meta-thorax and segments 1 to 7, a posterior band is present only on segment 8.

Mesothorax with dorsal anterior band transversely divided, anterior part with six to eight rows of setulae, posterior part with eight to ten rows, the two parts confluent laterally and continued over sides on anterior third of segment. Metathorax with dorsal anterior band similar but narrower and with its posterior part broadly interrupted medially. Segment 1 with dorsal anterior band of six to eight rows of setulae, band becoming obsolete laterally in front of spiracles. Segment 2 with dorsal anterior band of four to five sparse rows on median half only; segments 3 to 5 with similar bands which are smaller on each successive segment. Dorsal posterior band of segment 1 on median half only and with about three sparse rows of setulae; band larger on each successive segment, that of segment 6 on about median three-fourths and with five to six rows of setulae; band of segment 7 slightly smaller than that of segment 6.

Ventral anterior bands of meso- and meta-thorax compact, each with 12 to 14 rows of setulae, narrowed laterally but extending onto sides of segments; ventral anterior bands of segments 1 to 7 with setulae more sparse, not extending onto sides of segments, segments 5, 6 and 7 with successively fewer rows of setulae in band, that of segment 7 with about six rows. Segment 8 with five to six rows of strong, anteriorly directed setulae along posterior margin (Fig. 12c). Meso- and meta-thorax laterally with many closely-placed setulae which are almost entirely confined to the anterior third of the segment; segment 1 to 6 laterally with setulae sparse, scattered over most of the segments; segments 7 and 8 without lateral setulae.

Second antennal segment about twice as long as wide. Dorsal head sclerite absent. Thoracic and abdominal segments with median pair of dorsal papillae (3 and 4) without bristles. Segments 1 to 7 with papillae 1 and 2 (and 5 and 6) on a minute, partly divided tubercle.

Lengths of bristles of lower and upper pleural papillae and of dorsal papillae 1 to 3 as follows:

prothorax: 1.pl., 8μ; u.pl., 13μ; 1, 9μ; 2, 6μ; 3, –
mesothorax: 1.pl., 8μ; u.pl., 13μ; 1, 10μ; 2, 16μ; 3, –
metathorax : 1.pl., 9μ; u.pl., 18μ; 1, 10μ; 2, 11μ; 3, –
segment 1: 1.pl., 9μ; u.pl., 13μ; 1, 15μ; 2, 10μ; 3, –
segment 7: 1.pl., 11μ; u.pl., 10μ; 1, 12μ; 2, 12μ; 3, –

Segment 8 (Figs. 12b-d) much broader than long, tapering on posterior half, not constricted; bristle of dorsal papilla 19μ long, that of the single pleural papilla 15μ long. Spiracular processes of segment 8 oblique anteriorly, the sclerotization extending anteriorly along the entire length of the margin of the apical cleft of segment 8. Terminal papillae three pairs; inner pair each with a short, sclerotized peg, oval in posterior view, 10μ wide and 5μ long; middle pair each with a heavy, blunt, peg-like bristle 10μ long; outer pair each with a normal bristle 15μ long.

Sternal, lateral and pleural papillae of thoracic segments as in *C. banksianae* n. sp. (Fig. 13e) in number and bristling. Anal segment (Fig. 12c) with one ventral papilla on each side of anus.

Holotype.– ♂, Stead, Manitoba, May, 1957 (W. A. Reeks). Type No. 6832, Canadian National Collection.

Paratypes.–6 ♂♂, 4 ♀♀, 31 larvae, same data as holotype; 5 ♂♂, 6 ♀♀, (1 ♂, 1 ♀ with associated pupal skins) Black Sturgeon Lake, Ont., May 25 - June 21, 1958; 1 ♂, 1 ♀, Vermilion Bay, Ont., May 28, 1958; 1 ♀, Uxbridge, Ont., May 23, 1958; 1 ♀ with associated pupal skin and 2 larvae, Ottawa, Ont., April and May, 1959 (J. R. Vockeroth); 1 ♂, 2 ♀♀, Upper Michigan National Forest, Mich., May 5, 1952 (Eaton); 2 ♀♀, Manistee National Forest, Mich., April 13, 1946 (P. S. Newcomb & staff). In C.N.C., U.S.N.M., collection of H. F. Barnes, Rothamstead, England and collection of E. Möhn, Dauborn, Germany.

Other specimens examined.–2 pupal skins, Manistee National Forest, Mich.; males and females either dry on pins or too damaged to be designated as paratypes, from Fort Frances, Upsala and Sault Ste. Marie, Ont. and Belair, Man.

Habits.–The type and the adult paratypes from Stead, Black Sturgeon Lake, Ottawa and Upper Michigan National Forest were all reared from pupae in pitch masses of *Pinus banksiana* Lamb.; the other adults were reared from *P. banksiana* and the larvae were collected from the same species. Mr. W. A. Reeks, who is publishing a paper on the life history of the species, has kindly provided the following information: "Eggs laid on needles and shoots, not on pitch masses; larva in pitch mass; larva overwintering, pupating in spring." Five larvae that I collected at Ottawa in April, 1959 were all in the pitch exudation at the base of the buds; the pupa was formed in the pitch inside a very delicate cocoon.

***Cecidomyia banksianae* n. sp.**

Figs. 2, 5, 11, 13

Male.–Wing length 2.4 mm. to 2.8 mm. Very similar to *C. reeksi* n. sp., differing as follows:

Flagellar segments (Figs. 2a, 5a-c) very slightly more elongate, nodes a little less abruptly constricted to form the stems; fifth flagellar segment as in Fig 2a. Palpus (Fig. 2h) with three segments, proportions of segments about 10:21:34. Proportions of hind tarsal segments about 1.0:6.6:4.0:2.5:1.3.

Terminalia (Fig. 2b) with dististyle less strongly tapering, more blunt apically; sternite 10 with shallow apical emargination, depth of emargination from one-third to a little less than one-quarter width of sternite; aedeagus narrower, 0.039 mm. to 0.044 mm. wide, 0.63 to 0.73 as wide as sternite 10.

Female.—Wing length 2.9 mm. to 3.1 mm. Head, palpi, wings and legs as in male. Antenna (Figs. 5d-f) and ovipositor essentially as in female of *C. reeksi* n. sp.

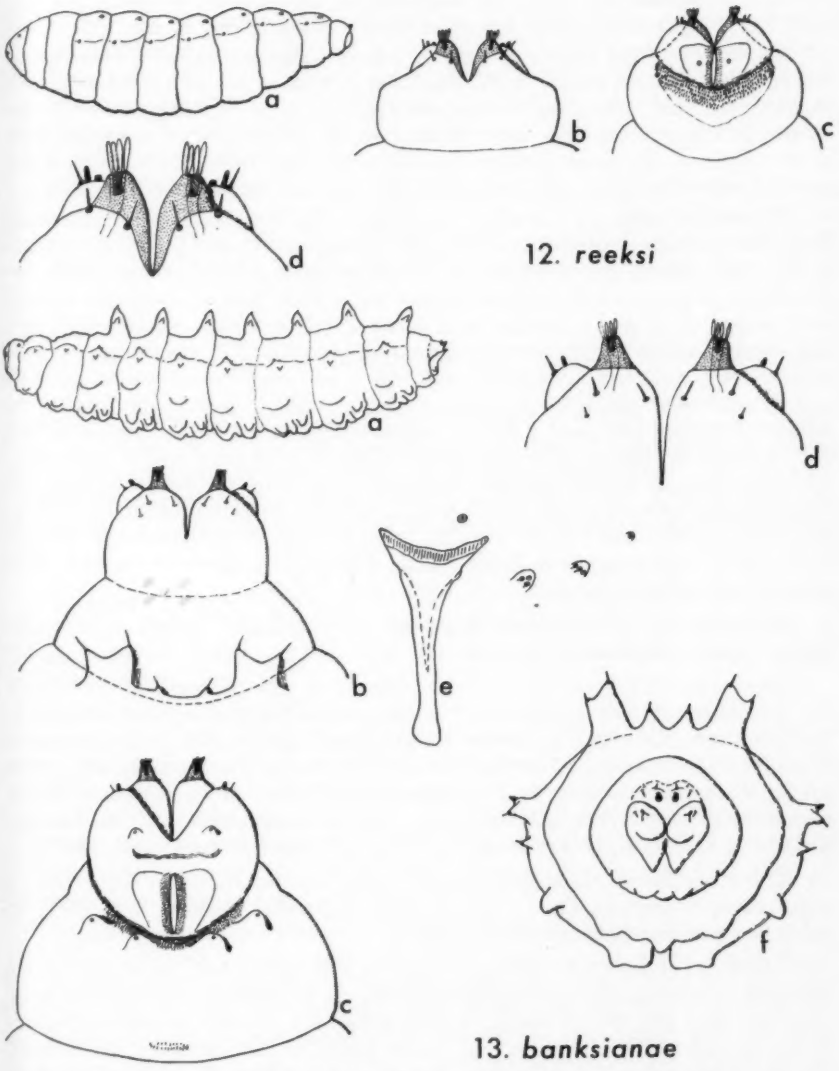
Pupa.—Length 2.4 mm. to 3.0 mm. Antennal horn (Figs. 11g, h) moderately long, subacute. Vertical tubercle (Fig. 11h) short, rather broad, uniformly sclerotized, with apical bristle. Median vertical process present. Thoracic respiratory horn (Fig. 11i) 0.14 mm. to 0.19 mm. long, only very slightly curved. Abdomen, in both sexes, either finely and uniformly shagreened or with darker transverse bands of variable size, formed of slightly coarser shagreen and pale brown underlying integument, along the anterior margins of the segments.

Larva (Fig. 13a).—Length 5.4 mm. Living larva bright orange-red in colour. Abdominal segments 1 to 7 each with a pair of long, partly divided, dorsal tubercles and a pair of shorter, submedian tubercles; sclerotized spiracular processes on tubercles; most pleural papillae on small but distinct tubercles; ventral surfaces of meso- and meta-thorax and of segments 1 to 7 each with an anterior and a posterior row of low, broad, rounded tubercles. Breastbone present.

Transverse setulose bands few in number, not extensive, their setulae very fine and pale. Meso- and meta-thorax and segment 1 each with a dorsal, anterior, unbroken band of six to eight rows of setulae, those on mesothorax extending laterad at least to level of upper pleural papilla, those on other two segments extending only to level of outer dorsal papilla; prothorax and segments 2 to 8 without dorsal setulose bands. Meso- and meta-thorax and segments 1 to 7 ventrally each with an anterior band of six to eight rows of setulae, these bands constricted by the anterior submedian tubercles. Segment 8 anteriorly with about twenty minute setulae in two irregular rows, posteriorly with about six rows of slightly stronger setulae lying immediately in front of the anus. Meso- and meta-thorax and segments 1 to 8 laterally with pale, minute, sparse, irregularly scattered setulae which extend farther dorsad on anterior and posterior parts of segments; on all but segment 8 these setulae are confluent ventrally with the anterior setulose bands.

Second antennal segment scarcely longer than wide. Dorsal head sclerite absent. Thoracic and abdominal segments with median pair of dorsal papillae (3 and 4) each with a bristle. Dorsal papillae of thorax not on tubercles. Segments 1 to 7 with dorsal papillae 1 and 2 (and 5 and 6) on a common, elongate, weakly bifid tubercle; dorsal papillae 3 and 4 each on a shorter but distinct tubercle which varies slightly in length; the four tubercles of each segment on a slightly raised, transverse, common base (Fig. 13f). Meso- and meta-thorax each with upper pleural papilla on a small tubercle, lower pleural papilla on a very small tubercle; segments 1 to 7 each with lower pleural papilla on a small tubercle, upper pleural papilla on a large tubercle which bears the spiracle on a small tubercle on its upper surface (Fig. 13f).

Lengths of bristles of lower and upper pleural papillae and of dorsal papillae 1 to 3 as follows:



Figs. 12, 13. Larvae. 12, *C. reeksi;* 13, *C. banksianae.* (*a*, larva, lateral; *b*, segment 8 and anal segment, dorsal; *c*, segment 8 and anal segment, ventral; *d*, apex of segment 8 and anal segment, dorsal; *e*, breastbone, and sternal, lateral and inner pleural papillae of left side; *f*, segments 7 and 8 and anal segment, posterior).

prothorax: 1.pl., 23μ; u.pl., 23μ; 1, 20μ; 2, 23μ; 3, 20μ
mesothorax: 1.pl., 20μ; u.pl., 25μ; 1, 23μ; 2, 18μ; 3, 20μ
metathorax: 1.pl., 21μ; u.pl., 27μ; 1, 24μ; 2, 20μ; 3, 20μ
segment 1: 1.pl., 32μ; u.pl., 25μ; 1, 30μ; 2, 30μ; 3, 26μ
segment 7: 1.pl., 26μ; u.pl., 25μ; 1, 25μ; 2, 24μ; 3, 24μ

Segment 8 (Figs. 13b-d) as long as broad, tapering, slightly constricted at mid length; bristle of dorsal papilla 26μ long, bristles of the two pairs of pleural papillae 12μ and 26μ long. Spiracular processes of segment 8 transverse anteriorly, the sclerotization not extending along the margins of the apical cleft of the segment. Terminal papillae two pairs, the inner each with a heavy, blunt, peg-like bristle 14μ long, the outer each with a normal bristle 18μ long.

Breastbone (Fig. 13e) concave anteriorly, 0.21 mm. long, 0.11 mm. wide. Prothorax without ventral tubercles, with sternal, lateral and pleural papillae as in Fig. 13e. Meso- and meta-thorax anteriorly each with a pair of small, approximated sublateral tubercles which bear the sternal papillae, on posterior half with a pair of larger, well-separated, partly divided, sublateral tubercles, each half of each tubercle with three lateral papillae; bristling of papillae as on prothorax. Segments 1 to 7 ventrally each with a pair of sublateral tubercles and a pair of submedian tubercles on anterior half, a median tubercle just behind the middle of the segment, and a pair of submedian tubercles on the posterior half; both pairs of submedian tubercles weakly divided by a longitudinal impression. The four anterior ventral papillae of segments 1 to 7 on the anterior submedian tubercles, the two posterior ventral papillae on the anterior sublateral tubercles. Segment 8 with four ventral papillae, each on low, broad, rounded tubercle (Fig. 13c). Anal segment with one pair of anal papillae which lie on very small, rounded tubercles posterolateral of anus (Fig. 13c).

Holotype.—♂, Stead, Manitoba, May, 1957 (W. A. Reeks). Type No. 6833, Canadian National Collection.

Paratypes.—3 ♂♂, 4 ♀♀, 6 larvae, same data as holotype; 2 ♂♂, 14 ♀♀ (2 ♂♂ and 6 ♀♀ with associated pupal skins), Black Sturgeon Lake, Ont., April 7 - June 25, 1958; 1 ♂, Dunns Valley, Ont., May 28, 1958; 1 ♂, Actinolite, Ont., May 13, 1958; 4 ♂♂ with associated pupal skins, Ottawa, Ont., May, 1959 (J. R. Vockeroth); 6 ♂♂, 4 ♀♀ (all with associated pupal skins), 26 larvae, Constance Bay near Ottawa, Ont., May, 1959 (G. Lewis and J. R. Vockeroth). In C.N.C., U.S.N.M., collection of H. F. Barnes, and collection of E. Möhn.

Other specimens examined.—3 pupal skins, 1 pupa, Dunn's Valley, Ont.; 2 pupal skins, Timagami, Ont.; 2 pupal skins, Actinolite, Ont.; 3 ♂♂ (dry, on pins) Kemptville and Fort Frances, Ont.

Habits.—The type and adult paratypes were all reared from pupae in cocoons on needles or shoots of *Pinus banksiana* Lamb.; the larvae were collected from the same species. Mr. W. A. Reeks, who is publishing a paper on the life history of the species (Reeks, in press), has kindly provided the following information: "Larva in excavation at base of bud, not causing swelling of twig, in pitch only when pitch exudes from the base of a needle; larva overwintering, pupating in spring in cocoon on needle or shoot."

Cecidomyia accola n. sp.

Figs. 3, 6

Male.—Wing length 2.8 mm. to 2.9 mm. Very similar to *C. reeksi*, differing as follows:

Flagellar segments (Figs. 3a, 6a-c) with distal stem slightly shorter in proportion to length of distal node, but apical segment with slightly longer apical tubercle; length and distinctness of proximal stem slightly variable. Palpus (Fig. 3d) with four segments, the second the longest; proportions of segments about 30:85:72:77. Proportions of segments of hind tarsus 1.9:8.0:5.2:3.1:1.4 (one tarsus only). Terminalia (Fig. 3b) with dististyle not strongly tapering, distal third tapering hardly at all, apex blunt; tergite 10 with broad but slightly shallower emargination; sternite 10 with very shallow emargination, depth of emargination one-sixth width of sternite; aedeagus very narrow, 0.033 mm. to 0.039 mm. wide, about 0.42 as wide as sternite 10.

Female.—Wing length 3.7 mm. to 3.8 mm. Head, palpi, wings and legs as in male. Antenna (Figs. 3c, 6d-f) similar to that of *C. reeksi* n. sp., but flagellar segments a little more elongate and longitudinal connectives of circumfila each with six to eight (usually seven) points of attachment. Ovipositor as in female of *C. reeksi.*

Pupa and larva unknown.

Holotype.— ♂, Espanola, Ontario, June 2, 1958. Type No. 6834, Canadian National Collection.

Paratypes.—1 ♂, 4 ♀ ♀, same data as holotype, in C.N.C.

Habits.—Dr. W. L. Sippell has informed me that the specimens of *accola* listed above were reared from branches of *Pinus banksiana* Lamb. which showed growth malformation near the base of new shoots. The damage resembled that caused by *C. banksianae* n. sp. but no cocoons were observed on the needles.

Notes on other species of *Cecidomyia*

Cecidomyia pini (Degeer) 1782.—I have examined one male from Sweden, reared from *Pinus.* The adult was described by Kieffer (1913), the larva (as *Itonida pini*) by Möhn (1955b); male terminalia (as *Itonida pini*) were figured by Möhn (1955a).

Cecidomyia piniinopis Osten Sacken 1861 (usually written as *inopis* O.S.).—I have examined two males and one female (Falls Church, Va., emerged May 2-26, 1917, from pine), and three females (Hopkins No. 14800a, no other data). All are in the U.S.N.M., and all were determined as *resinicola* (O.S.). The palpi and fifth antennal segment of the males agree with sketches of these structures in *piniinopis* sent to me by Dr. Foote. The terminalia of the males were mounted laterally and could not be examined. Dr. Foote (in litt.) has told me they do not differ from those of *banksianae* n. sp.

Cecidomyia resinicola Osten Sacken 1871.—I have examined one male (May 31, 1879) and one female (June 13, 1879), both reared from *Pinus inopis* (= *virginiana*) but without locality data. Both are in the U.S.N.M.; the male palpi and fifth flagellar segment agree with sketches of these structures made by Dr. Foote from a specimen compared with the type by E. P. Felt. The terminalia of the male appear identical with those of the male of *reeksi* n. sp. Osten Sacken (1871) said of the larva "breastbone . . . not apparent"; Kieffer (1913) described the larva in detail and stated that the breastbone was absent. It seems probable, therefore, that the structure figured by Eckel (1903) as the "breastbone" of the larva of *resinicola* (if the species on *P. rigida* is actually *resinicola*) was in fact a dorsal head sclerite similar to that of the larva of *C. albitarsis* (Felt) [Fig. 9k]; it closely resembles the latter structure and differs greatly from any breastbone known to me.

Cecidomyia resinicoloides Williams 1909.–I have examined one male from the U.S.N.M. (Stanford Univ., Cal., 4 Apr. 1908, coll. R. W. Doane); it is almost certainly part of the type series. The larva was described by Williams (1909, 1910).

Cecidomyia albitarsis (Felt) 1918, new combination.–I have examined one male and five females (three with pupal skins), Belleville, Ont.; five females, Flanagan Road, York Co., N.B.; 13 larvae, Old Chelsea, Que.; 16 larvae, Ottawa, Ont. All are from pitch masses of *Pinus strobus*.

Summary

The generic assignment of the species of Cecidomyiidae known as resin midges or pine pitch midges is discussed; the genera *Retinodiplosis* Kieffer and *Stelechodiplosis* Möhn are treated as subjective synonyms of *Cecidomyia* Meigen. The genus *Cecidomyia* is redescribed, and the generic assignments of the species from *Pinus* apparently incorrectly referred to *Cecidomyia* are discussed. Keys to the larvae, pupae and males of the Nearctic species of *Cecidomyia*, and to the females of the species occurring on *Pinus banksiana*, are given. The three species known to occur on *P. banksiana* are described as new from specimens from Manitoba, Ontario and Michigan; larvae and pupae of two of the species are also described.

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A Method of Adapting a Microscope for Observation of Non-Motile Insects on Tree Trunks[1, 2]

By R. C. Clark[3] and N. R. Brown[4]

Field studies on adelgids and other small non-motile insects living on the bark of trees are often hampered by insufficient magnification and poor light when a hand lens is used. We have tested various commercial illuminated magnifiers but have found that they are either of too low magnification or have too shallow a depth of field.

The use of a microscope is desirable but calls for a simple method of attachment. This problem has been solved cheaply and conveniently with an old style low power binocular microscope equipped with a U-shaped base.

The microscope (Fig. 1) was removed from the base by unscrewing the knurled wheel in the lower part of the supporting arm. Small metal plates, measuring 1¼ in. by 2¼ in. (Fig. 1,A), drilled and tapped the same as the U-shaped base were made. Three counter-sunk holes were also drilled in the plates to receive brass wood screws used in attaching the plate to a tree. The microscope could then be fastened to the plate.

The problem of illumination was solved by attaching a light metal arm (Fig. 1,B) to the microscope body above the revolving objective lens mount. To the end of this arm a pivoting clamp (Fig. 1,C) is attached which grips a two-cell flashlight.

The microscope is carried to the field in a box (larger than the box for this microscope) and is mounted on a plywood base to which one of the plates described above has been attached. By setting the microscope obliquely on the base it is possible to leave the flashlight-bearing arm and flashlight attached.

[1]Contribution No. 580, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.

[2]Part of a joint project of Forest Biology Division, Fredericton, N.B. and Department of Lands and Mines of New Brunswick, financed in part by funds from the Provincial Department.

[3]Research Officer, Forest Biology Laboratory, Fredericton, N.B.

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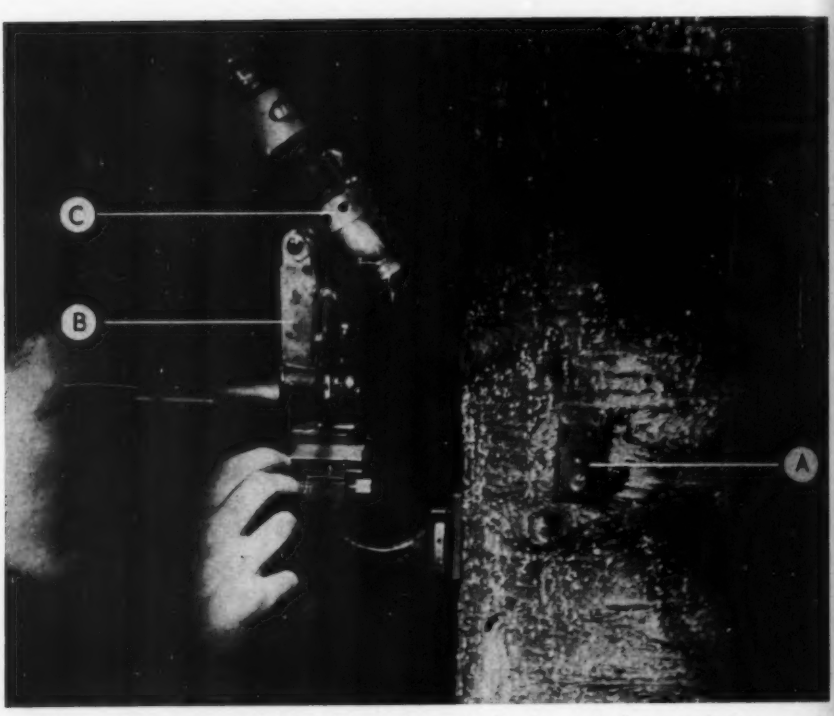

Fig. 1. Microscope used for field sampling. A. Small metal plate attached to trunk. B. Metal arm used for flashlight attachment. C. Pivoting clamp for holding flashlight.

In the field a suitable area of bark is located and the place for attachment of the metal plate is found approximately by focusing the microscope on the desired study area. With the low power objectives a circular field of almost ⅝ in. is obtained; this is sufficient to follow the development of at least two dozen well-separated adelgids. For sampling purposes this serves to delimit the unit area without marking. The same area is automatically selected each time.

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